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BARLEY - HOG RATIO FOR SASKATCHEWAN[1]

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Most students of farm management in Canada are familiar with what is known as the "corn-hog ratio", which is used so extensively in the United States for indicating probable changes in trends of hog production. Many studies have been made by state agricultural colleges and the United States Bureau of Agricultural Economics dealing with this ratio. As corn is the most important feed for hogs in the United States it has been found that the relationship between corn prices and hog prices is a major factor causing increases or decreases in hog production. This relationship, as expressed in the corn-hog ratio, is the number of bushels of corn at farm prices which equals in value 100 pounds of live hogs at farm prices. The ratio varies from month to month depending upon the relative prices of corn and hogs. Monthly ratios and yearly average ratios are published in "Crops and Markets," a monthly publication of the United States Department of Agriculture.

This paper is the result of a statistical study of the relationship between the farm prices of barley and the farm price of live hogs in Saskatchewan for the period 1910 to 1932. In Canada barley generally takes the place of corn as a feed for swine, and, apart from screenings and low grade wheat and oats is probably fed in larger volume than other grains in Saskatchewan. For these reasons it was considered that the ratio between barley prices and hog prices would serve as the best single indicator of probable expansion and contraction of swine production in this province.

The barley-hog ratio for Saskatchewan is simply the average monthly farm price of 100 pounds of live hogs divided by the average monthly farm price of barley per bushel, and is expressed as so many bushels of barley equal in value to 100 pounds of live hogs. The monthly and average yearly ratios are indicated in Table 1.

The farm prices for No. 3 C.W. barley and for hogs were calculated on the basis of the Saskatoon district because of its central location in the province. Throughout the whole period Winnipeg prices, fed and watered basis, were used for calculating the farm price of hogs for Saskatchewan. From 1910 to 1922 the price of "Choice Hogs" was used because it was assumed that this was representative of the price received by the average producer.

Due to the fact that Winnipeg prices were not quoted for the period 1910 to 1912 it was necessary to compute the probable Winnipeg price for

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these years by taking the Toronto price of this period and deducting 50 cents for the first six months of the year, and 51 cents for the last six months. The spread between Toronto and Winnipeg prices was found to be about 50 cents during 1913 and 1914. Over the period studied the grading system for hogs changed. Accordingly after 1922 "Thick Smooth" hogs were taken as the nearest grade approaching "Choice Hogs", and from September 1929 on "Bacon Hog" prices were used.

TABLE 1.—*Number of bushels of No. 3 C. W. barley (farm prices) to equal in value 100 pounds of live hogs (farm prices) for Central Saskatchewan, 1910 to 1932.*

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Aver.
1910	20.6	18.8	21.1	23.8	23.4	27.8	21.2	24.7	23.0	22.3	17.9	17.7	21.9
1911	16.8	14.3	11.6	9.3	8.5	10.8	12.6	12.3	10.0	8.2	9.6	10.8	11.2
1912	9.6	10.0	11.7	12.2	13.6	15.1	16.6	19.2	18.8	16.8	17.9	20.8	15.2
1913	22.3	21.0	22.4	21.8	23.8	23.8	23.1	26.8	25.3	26.9	24.9	24.5	23.9
1914	24.9	23.7	24.6	23.8	21.1	16.8	16.9	16.7	15.8	12.4	10.2	12.0	18.2
1915	10.2	10.0	10.3	13.3	12.6	13.5	13.4	15.4	21.9	18.6	13.8	16.0	14.1
1916	16.0	16.4	20.2	21.4	18.7	17.1	16.5	17.2	14.9	10.8	10.0	12.0	15.9
1917	13.3	15.8	15.1	13.9	13.8	12.6	12.5	14.9	15.9	15.0	13.4	13.7	14.2
1918	14.2	12.2	11.4	12.8	15.0	15.4	14.9	18.9	18.7	19.5	17.9	20.2	15.9
1919	20.0	23.8	22.5	21.7	19.5	17.6	18.8	17.0	15.6	13.8	11.2	10.6	17.7
1920	10.1	11.4	12.7	12.0	12.4	10.3	11.4	15.2	19.5	19.0	16.9	17.4	14.0
1921	18.4	20.2	20.4	22.6	18.8	16.6	18.5	22.1	24.9	27.5	23.9	23.4	21.4
1922	24.7	25.8	23.3	22.7	22.9	25.1	25.1	25.8	25.1	22.4	21.6	20.3	23.7
1923	20.6	20.4	19.5	20.4	20.8	19.2	21.5	22.7	24.4	20.2	17.0	15.3	20.2
1924	13.5	12.5	13.0	13.0	12.3	12.3	9.8	11.6	10.6	10.6	10.1	10.6	11.7
1925	11.1	11.5	16.3	16.9	13.6	14.6	15.7	17.7	22.7	21.9	20.6	22.7	17.1
1926	25.1	27.4	26.8	25.0	26.9	28.4	26.6	23.2	23.0	21.4	18.5	19.0	24.3
1927	18.2	17.7	16.5	13.9	11.6	10.1	10.9	13.8	16.5	13.4	10.5	9.9	13.6
1928	10.2	10.2	10.0	10.5	11.4	12.6	14.8	21.7	22.0	15.2	14.2	15.1	14.0
1929	14.1	14.3	16.4	18.7	21.5	19.0	17.4	18.5	17.1	16.8	18.3	19.5	17.6
1930	24.1	30.6	32.3	29.8	32.4	40.2	40.0	40.0	55.5	64.5	83.5	66.8	45.0
1931	88.3	74.8	51.4	43.5	37.1	36.1	38.5	29.5	24.6	19.8	11.9	12.6	39.0
1932	13.2	13.3	12.5	11.0									

Freight rates on grains and livestock were obtained from the Canadian National and the Canadian Pacific Railways for the period studied.

From the Winnipeg prices of hogs the following items were deducted:—

(1) The various freight rates per 100 pounds that have been in force during the period studied.

(2) Feeding charges.

(3) Condemnation insurance.

(4) Other charges including commissions, yardage, loading and unloading, and fire insurance.

(5) Expenses of man going with car from Saskatoon to Winnipeg.

Feeding charges varied from month to month according to the price of barley. Government regulations stipulate that the charge shall not exceed the average wholesale market value of the feed the preceding month, plus $10.00 per ton profit and $4.50 per ton for handling. The price of barley

used in calculating feeding charges was the Fort William price of No. 3 C. W. barley plus freight from Fort William to Winnipeg. It was assumed that each hog would consume 8 pounds of feed.

Condemnation insurance is insurance against the death of hogs during transport and against hogs being discarded at the yards for disease or other reasons. It was calculated on the basis of ½ of 1% of the average monthly market price for hogs.

Other charges were calculated on the basis of a carload of 80 hogs, each weighing 200 pounds.

(1) The commission charge was $10.00 per car.

(2) Yardage charge was 8 cents per head on carload lots

(3) Fire insurance amounted to 15 cents per carload.

(4) A two dollar stockyard charge was allowed for loading and unloading.

(5) The expense of a man going with the car from Saskatoon to Winnipeg for the period 1910 to 1919 was estimated at $16.00 per trip. From 1920 to 1931 the cost was estimated at $24.00 per trip.

The farm price of No. 3 C. W. barley was the Fort William price less the freight rate from Saskatoon to Fort William and an elevator handling charge of 2½ cents per bushel.

Regarding the spread between the Winnipeg price and the calculated farm price it will be noticed that the average spread in 1910 was 64.8 cents per 100 pounds and reached a high point in 1920 of 95.2 cents (Figure 1). From this peak it dropped to 77.8 cents per 100 pounds in 1923 and settled around 74 cents in the latter part of 1931, about 9 cents higher than 1910. These fluctuations are mainly due to freight rates. Rail rates were 32 cents per 100 pounds at the beginning of the period. In 1918 they rose to 39 cents and reached a high point of 52½ cents in 1920. By the end of 1921 they had fallen to 39 cents per 100 pounds and have since remained at that level. The change in the cost of the man with the car in 1920 from $16.00 to $24.00 also had an effect on the spread. On the whole the other charges were probably less in the latter part of the period than in the first 10 years. It should be borne in mind that these charges are based on carload lots of 80 hogs. The individual farmer is not likely to ship such a large number of hogs at one time and thus his charges will probably be slightly higher.

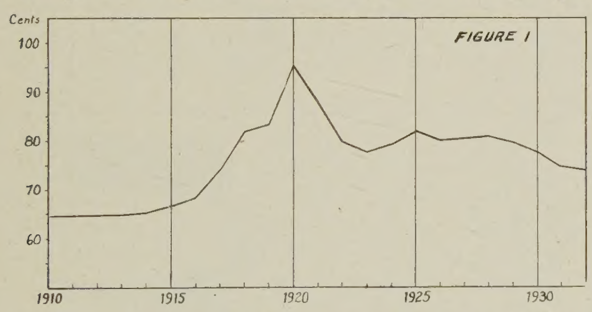
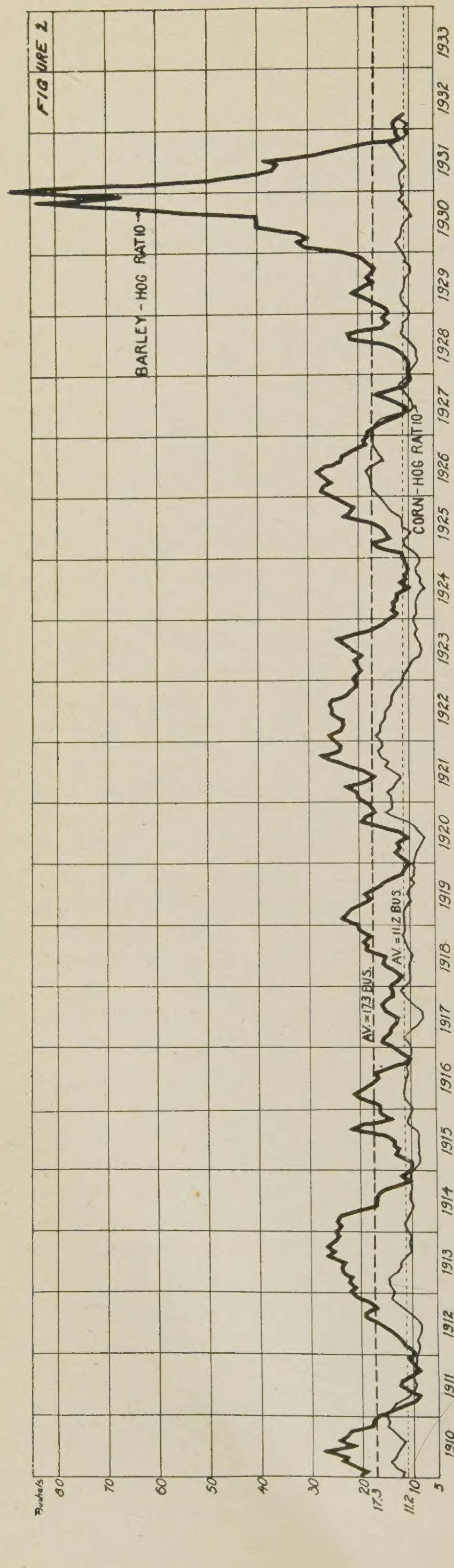
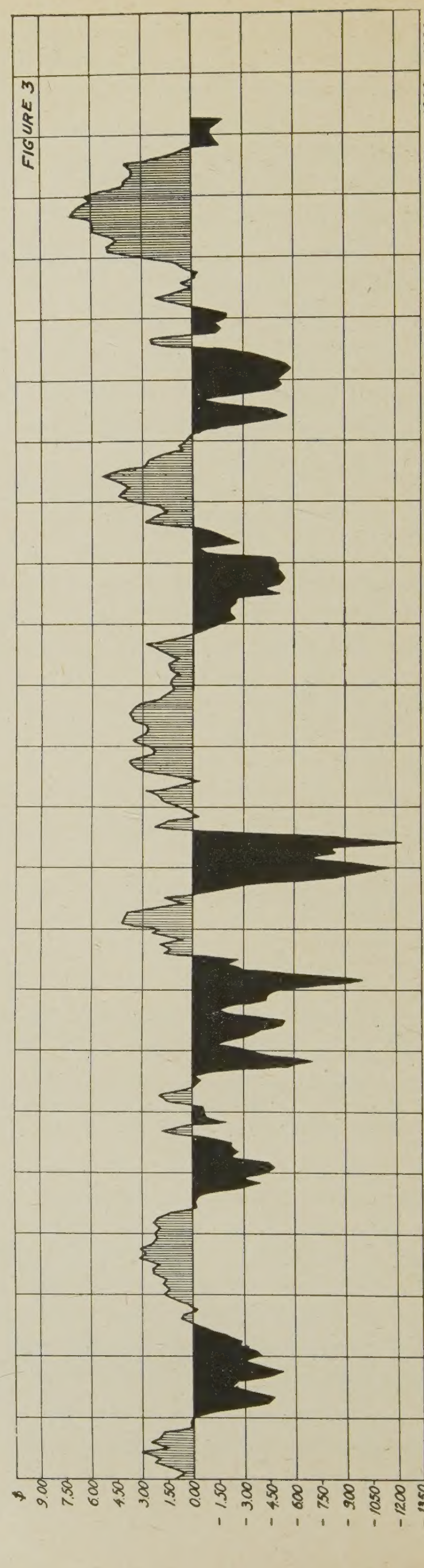


Figure 1. Average yearly spread between the Winnipeg price and calculated farm price per 100 pounds of live hogs for Saskatchewan. 1910 to 1932

The spread was 64.8 cents per 100 pounds in 1910 and 74 cents at the end of the period. The fluctuations are mainly due to freight rate changes.

The barley-hog ratio fluctuates from time to time because of the variation in the price of both barley and hogs. When the price of barley is high and the





See foot of opposite page for explanation of Figures 2 and 3.

price of hogs is low, it is quite obvious that fewer bushels of barley would be required to equal in value 100 pounds of hogs than when barley is low and hogs are high. For example in October 1911, it took 8.2 bushels of barley (at farm price) to equal 100 pounds of hogs in value, while in June 1910, it took 27.8 bushels of barley to equal in value 100 pounds of hogs. (Figure 2).

For the period 1919 to 1929 inclusive, 17.3 bushels of No. 3 C. W. barley on the average were required to equal 100 pounds of hogs at farm prices for central Saskatchewan. The ratios for 1930 and 1931 were left out of the average; because of the very low price of barley for these years it was considered that the extremely high ratios during these 24 months would have an undue weight in the average. Until 1930 the ratio had a fairly regular up and down movement fluctuating between 8.2 and 28.4 bushels, with no very violent deviations. This recurring cycle is somewhat irregular usually varying from 30 to 50 months from peak to peak.

In November 1930 it required 83.5 bushels and in January 1931, 88.3 bushels of barley to equal in value 100 pounds of hogs. The violent fluctuations during these two years might be compared to the relatively favorable period for hog producers during the post-war period 1921 to 1923. In the later part of 1920 the price of grains dropped quite rapidly. Hog prices did not drop relatively as much and a fairly favorable period was enjoyed till the fall of 1923. For the year 1930 hog production was comparatively profitable. Hog prices were relatively high due to a scarcity of hogs. Barley prices were low making hog production a very profitable enterprise. These factors both tended to make hog production more profitable during this year than at any other time during the period studied.

An interesting comparison was made of the barley-hog ratio for Saskatchewan, and the United States corn-hog ratio for the period 1910 to 1929 inclusive. For this period 11.2 bushels of corn were required to equal in value 100 pounds of live hogs (Figure 2). It will be noticed that the corn-hog ratio fluctuates fairly closely with our barley-hog ratio. For the period 1910 to 1929 inclusive the coefficient of correlation between these two ratios was $+ 0.62 \pm .027$. The corn-hog ratio averages lower than the barley-hog ratio because of the greater weight per bushel and higher feeding value per pound of corn. The coefficient of variability for the barley-hog ratio was 28.9, and 22.7 for the corn-hog ratio. Our ratio fluctuates relatively more than the corn-hog ratio probably because of the distance of central Saskatchewan

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Explanation of Figures 2 and 3 on opposite page.

Figure 2. Barley-hog ratio for Saskatchewan and corn-hog ratio for the United States at farm prices. 1910 to 1923.

Average (1910 to 1929 inclusive) value of 17.3 bushels of barley = value for 100 pounds of live hogs. Value of 11.2 bushels of corn = value of 100 pounds of live hogs for United States. Cyclical fluctuations in the barley-hog ratio range from 30 to 50 months from peak to peak. During the period studied the most favorable year for hog producers was 1930. The coefficient of correlation between the barley-hog ratio and the corn-hog ratio is $+ 0.62 \pm .027$.

Figure 3. Fluctuations of the differences between the value of 17.3 bushels of barley and the value of 100 pounds of live hogs at farm prices for the corresponding months for central Saskatchewan. 1910 to 1932.

Values above and below the zero line may be said to indicate the approximate gains and losses per 100 pounds of hogs. Both gains and losses are somewhat exaggerated because costs other than feed do not fluctuate with the price of barley.

from Fort William and Winnipeg, whereas the ratio for the United States farm price is based upon many markets some of which are local in character.

Another way of expressing the favourableness or unfavourableness of the barley-hog ratio is to indicate the actual dollars and cents difference between the value of 100 pounds of hogs and 17.3 bushels of barley (Figure 3). The value of 17.3 bushels of barley is calculated for each month and the difference between this and the value of 100 pounds of hogs for the corresponding month is charted. Therefore for the period 1910 to 1929 inclusive the total values above the line equal the total values below the line. When it requires more than 17.3 bushels of barley to equal in value 100 pounds of hogs then hog prices are comparatively high and hog production profitable. If it requires less than 17.3 bushels then hogs are comparatively low priced and not so profitable. The low point is – $12.34 per 100 pounds in June 1920 and the high point is +$7.26 in September 1930.

It will be noticed that the curve dropped below the zero line in November 1931. However a dip such as occurred in 1920 is hardly to be expected because of the very low prices for hogs unless barley prices should take a very drastic rise in the next twelve months.

Economists generally agree that over a long time period a product sells for its approximate cost of production under a condition of free competition. By cost of production is meant cash expenses, unpaid labor, interest and depreciation. Unless a product sells at a price to cover all these charges over a period of time, its production would not be continued. There are times when it will sell for considerably more and other times for considerably less than the cost of production. The selling price at any one time does not depend upon the cost of production.

Based on the barley-hog ratio alone, we might say that on the average, over a long period, the value of 17.3 bushels of No. 3 C. W. barley is approximately equal to the cost of production of 100 pounds of live hogs. Following this reasoning the dollars and cents values above and below the zero line show the approximate gains and losses per 100 pounds of hogs. Owing to the fact that feed is only a part of the total costs, however, the chart somewhat exaggerates both estimated gains and losses.

Summary

1. For the period 1910 to 1929 inclusive 17.3 bushels of No. 3 C. W. barley have equalled in value 100 pounds of live hogs on Saskatchewan farms.

2. The coefficient of correlation between the Saskatchewan barley-hog ratio and the corn-hog ratio for the United States is $+ 0.62 \pm .027$.

3. The Saskatchewan barley-hog ratio is more variable than the corn-hog ratio. The coefficient of variability for the barley-hog ratio is 28.9 and that for the corn-hog ratio in the United States is 22.7.

4. Based on the Saskatchewan barley-hog ratio alone the value of 17.3 bushels of No. 3 C. W. barley (farm price) is approximately equal to the cost of production of 100 pounds of live hogs (farm price).

5. The period covering 1930 and most of 1931 was relatively the most profitable for hog production in Saskatchewan since 1910.

The following problems are suggested by this short paper as useful fields for further statistical study. (1) The relationship between the barley-hog ratio and the hog price cycle. (2) The relationship between the barley-hog ratio and increases or decreases in hog population. (3) The relationship between the barley-hog ratio and hog marketings. These are studies which might considerably increase the value of the barley-hog ratio as a guide in adjusting hog production in Saskatchewan.

Acknowledgements

The writer wishes to acknowledge the suggestions and helpful criticisms of Dr. W. Allen and Professor E. C. Hope, in the preparation of this paper.

CURRENT PUBLICATIONS

AGRICULTURAL RUSSIA AND THE WHEAT PROBLEM. Vladimer P. Timoshenko. Published jointly by the Food Research Institute and the Committee on Russian Research of the Hoover War Library, Stanford University, California. Price $4.00.

This volume, appearing as Publication No. 1 of the Grain Economics Series of the Food Research Institute, should go far towards furnishing the background against which many of the details of the Russian picture may be made to assume their proper perspective. In the confused picture which has been placed before us, the eye has been led from one garish feature to another and for most of us the mind has registered like a poorly exposed photographic plate; the high lights are there, but the middle distances and the background are lacking.

Dr. Timoshenko was formerly Professor of Economics at the Ukrainian University of Prague and is now Lecturer in Statistics and Economics at the University of Michigan. His book has been prepared with a knowledge of the social and economic history of the Russian people. Through his association with the Committee on Russian Research of the Hoover War Library he has had access to an abundance of material not only at Stanford University but wherever it was available. He has drawn freely on official Soviet statistics and statements of policy, evaluating them in the light of his own knowledge and that of many of his Russian confreres now holding positions in United States institutions. The result is a picture of the situation which must be drawn in reasonably true proportions.

The general conclusion, that Russia will be a serious factor in the export wheat market only intermittently, was previously announced in the March and April, 1932, issues of Wheat Studies of the Food Research Institute. We now have a better understanding of many of the factors leading to this conclusion which is generally accepted in Canada at the present time, so generally that one is inclined to wonder if the wish is not father to the thought. Those whose business it is to really think on the subject will find their task made easier by the vast amount of work which has gone into the making of this volume. Much of the material included is not available in its original form to Canadian students. What material is available may henceforth be analysed with a much better idea of its true value now that we have this exhaustive study. The information is presented in five hundred and seventy-one pages, including four maps, ten charts and fifty-four tables. It is well indexed and well printed, a credit to the author, the institution he represents, and the Stanford University Press.—H. L. Trueman.

SOME OBSERVATIONS ON THE DEVELOPMENT OF THE CAECAL WORM, *HETERAKIS GALLINAE* (GMELIN, 1790) FREEBORN, 1923, IN THE DOMESTIC FOWL[1]

Alex. D. Baker

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Introduction

A review of the literature dealing with the development of *Heterakis gallinae* in the fowl reveals some very conflicting observations. In addition, there has been considerable confusion between *Heterakis gallinae* and several other allied species, particularly *Heterakis papillosa*. The name *Heterakis vesicularis* is now happily recognized as a synonym of *H. gallinae*. *Heterakis papillosa* is not recorded as a parasite of the chicken (Cram (*3*)), and the equal spicules of the male make this species readily distinguishable from *Heterakis gallinae*. It must necessarily be assumed that the studies made of *Heterakis papillosa* in the fowl in all probability refer to *Heterakis gallinae*.

In addition to the problem of misidentification of species, it is remarkable to what extent the findings of the various workers diverge. Herein the writer, in presenting a series of observation on the development of these worms, has accompanied his studies with close comparisons of the work of others in an endeavor to find the points of agreement and to try and offer an adequate explanation for some of the more glaring discrepancies that appear to exist.

Leuckart (*6*) is generally credited with being the first to investigate the life cycle of this worm. From his experiments he concluded that development of the worm was direct and that no intermediate host was required.

Railliet and Lucet (*7*) carried out experiments with artificial infestations and succeeded in recovering fifteen specimens of *Heterakis papillosa* on the 31st day. They recorded an infested bird suffering from diarrhoea a few days after the feeding of the worm eggs.

Ackert (*1*) was successful in infecting chickens with *Heterakis papillosa* by feeding them dung earthworms (*Helodrilus gieseleri hempeli* Smith) from the poultry yard. The embryonated round worm eggs apparently adhered to or were carried within the bodies of the annelids.

Riley and James (*8*) found that "complete development of the worms was attained by the twenty-fourth day." Graybill (*5*) states that "it will be noted that worms reached maturity in 57 days." Uribe (*9*) records that, "Females with eggs which were found 56 and 61 days after the ingestion of ova are considered to represent the completed adult stage," but he also considered that, "The data at hand are insufficient to establish the exact period necessary to the completion of development." Dorman's (*4*) findings were "that the period of the life cycle consists of not more than 36 days plus the time required for the incubation of eggs." All the authors referred to in this paragraph record working with *Heterakis papillosa*, but there appears to be little reason for not believing, from their descriptions of the parasites they were working with and from the fact that they were experimenting with

[1] Part of Animal Parasite Investigation at Macdonald College receiving financial assistance from the National Research Council of Canada.

chickens, that they were dealing with the same species as is herein under consideration, i.e., *Heterakis gallinae.*

From the above brief review it will be noted that a choice is offered ranging from 24 to 61 days as the time limit required in which these worms are able to reach maturity within the chicken.

Experimental and Discussion

Previous studies of the life cycle of *Heterakis gallinae* by Baker, Conklin, Maw, and Fogerty (*2*), indicated that the time required for completion of development of the worm within the chicken did not appear to be as high as that recorded by Graybill (*5*) or by Uribe (*9*). However, the approximate agreement of both these latter workers and the general accuracy of their other observations indicated that either (1) they were working with some species other than *H. gallinae,* or (2) some undetermined factor was exerting a marked influence on development. The first possibility has already been referred to and appears unlikely; the second seems to warrant consideration.

During the course of several experiments with *Heterakis gallinae,* the writer has found frequent opportunities of observing the development of this worm. All chickens used in experimental work, except the controls, were artificially infested with large doses of caecal worm egg material which had been embryonated in aerated 2% solutions of potassium dichromate.

During the early stages of the life of the worm it has been found to be rather closely associated with the caecal mucosa and some injury to the glandular epithelium may occur (Figure 2). Riley and James (*8*) record that "within 4½ hours emerged larvae were to be found in the small intestine. At the end of 24 hours they were present in numbers in the ceca. At this time they measure 250 microns in length to 18 microns in maximum width." Figure 1 represents the newly emerged larva and agrees fairly well with the descriptions given by Graybill (*5*) and Uribe (*9*), although the former records the length as being from 290-340 microns, and the latter found larvae in the caecal contents 24 hours after infestation measuring 180 microns. Some growth would seem to have occurred to justify some of the longer measurements, as the newly emerged larva is not usually much longer than three times the length of its egg case; but recorded measurements of egg size differ also.

The close association of the worm with the glandular crypts of the mucosa has not been observed to extend much beyond the 4th day after infestation. Worms are usually recovered readily from the caecal lumen thereafter. Drawings of worms recovered from infested stock on the 5th to 10th days are given in Figure 3. As the scale of magnification is indicated directly on the drawings comparisons can be made readily. One of the examples in Figure 3 has been given greater enlargement in order to show more detail. The alimentary tract is clearly visible and the bulb of the oesophagus is already indicated in the larger specimens. The range of growth will be noted.

After the stages of development shown in Figure 3, growth is usually accelerated very considerably. The drawings of worms recovered from infested stock 12-19 days after infestation are shown in Figure 4 and indicate this rapid growth rather clearly. The agreement with other workers at this point is quite marked. Riley and James (*8*) have noted that, "by the tenth

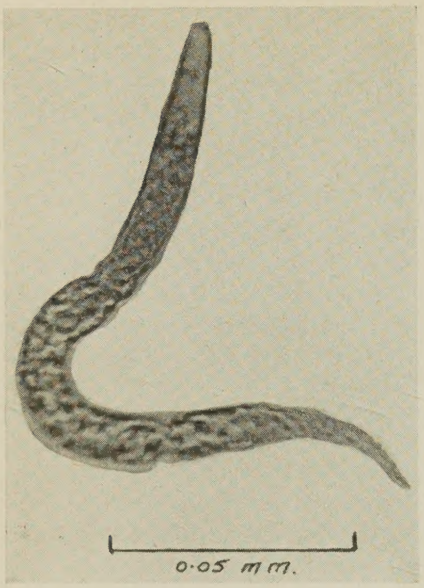


Figure 1. Photomicrograph of young larva immediately after emergence from its egg case.

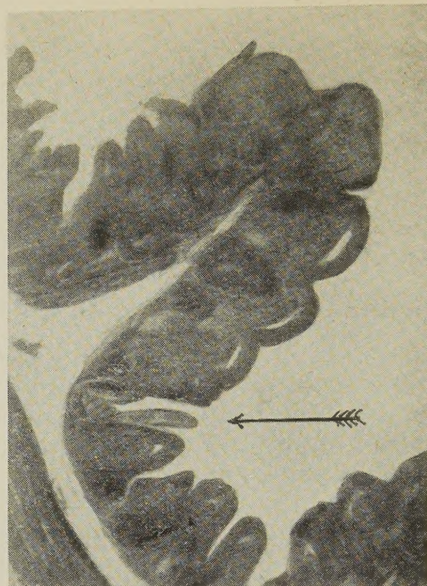


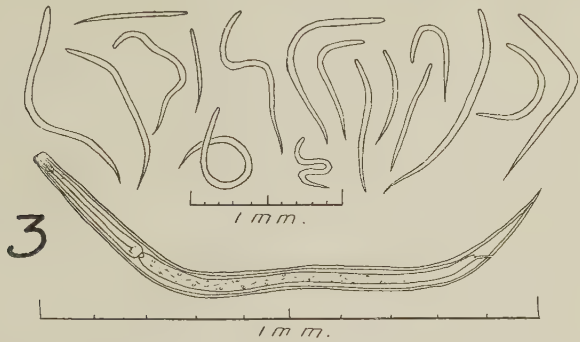
Figure 2. Photomicrograph of young caecal worm invading the mucosa of the caeca of fowl.

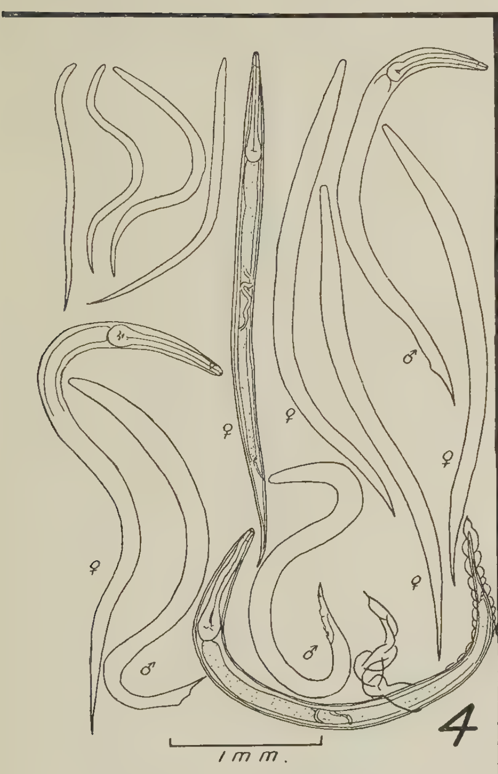
day the larvae in the ceca had increased greatly in length, measuring 790 microns . . . .", and Graybill (*5*) has also recorded a marked growth by the 7th, 9th and 10th days. Uribe (*9*) found that, "by the ninth day the rate of growth shows a sudden acceleration and moulting individuals are found." The bulbous oesophagus is well developed at this stage and the sexes can usually be rather clearly distinguished. Evidences of the external male structures at this stage have not been previously recorded. Both the male and female internal genital structures can also be seen to be considerably developed at this time. Uribe (*9*) found that the female worm showed groups of cells in the middle portion corresponding to the genital organs on the 9th day, and Riley and James (*8*) record the gonads as being outlined by the 10th day. By the 11th day Uribe (*9*) observes that, "there are several coils of the genital appartus apparent at the middle of the body." Up to this stage the present findings appear to be fully supported by other workers. At this time the papillae are quite conspicuous, more so than in the later stages, and the formation of lips is evident in several cases.

From the above it can be seen that fairly general agreement exists regarding the development of the worm up to the point described. It is from the stage just recorded up until maturity of the worm that the greatest differences in recorded observations are found to occur.

A study of these worms over the 15-22 day period (Figure 5) shows the range of growth which may occur at this time. Development of the lip structures is now general. Graybill records the formation of "chitinous structures" at the anterior end of the oesophagus by the 16th day. This triple structure is quite conspicuous after the second week and appears to precede lip development somewhat.

The worms shown in Figure 6 represent specimens of worms recovered 26-33 days after infestation. The birds from which these worms were recovered were all autopsied on the same day but infestation had been spread over a period of a week. The variation in development can be seen to be very marked indeed. Worms of the type shown in Figure 6b are clearly mature





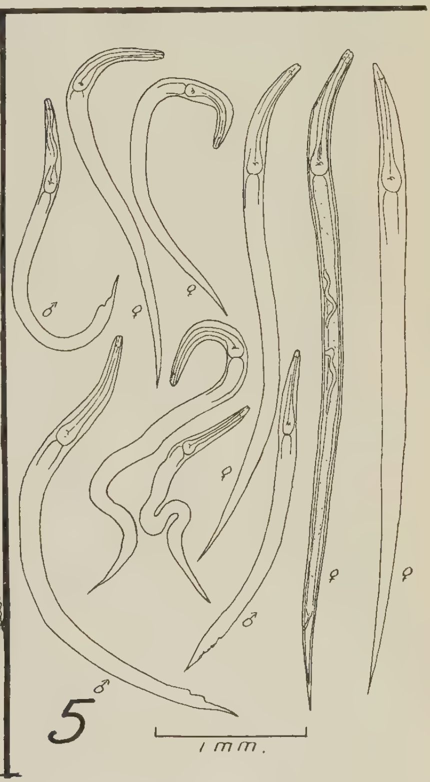


Figure 3. Examples of worms recovered from the caeca of chickens 5-10 days after infestation.

Figure 4. Drawings of worm larvae 12-19 days of age. It will be noted that the sexes can be distinguished. One specimen can be seen in the act of moulting.

Figure 5. Drawings of worm larvae 15-22 days of age, to show their range of growth and development during this period.

worms. An abundant supply of eggs could be noted within the bodies of such female worms. By comparison with the scale of magnification given, the size of this specimen may be noted (about 6.5 mm.). Graybill (*5*) has recorded that the worms reached a maximum of 4.5 mm. in length by the 29th day and that by the 37th day some worms were "about half grown." Dorman (*4*), on the other hand, recovered female and male worms which averaged 8.2 and 6.2 mm. in length, respectively, on the 36th day. The females were filled with eggs, and eggs had appeared in the droppings of the experimental birds at this time. As he had also found that the average length of caecal worms recovered during routine collections were 8.9 mm. for the females and 6.6 mm. for the males, Dorman concluded that the period of life within the bird was not more than 36 days.

From the drawings of Figure 7 (33-40 days) it will be seen that growth of the worms may progress considerably beyond the stages shown in Figure 6. Caecal worms of this greater size are by no means exceptional and they can be found quite readily over the 33-40 day period. The adult average sizes recorded by Dorman (*4*) appear to be rather small. It is also to be observed that the time required for the development of the worms in Figure 7 is still considerably under that which was deemed necessary by Graybill and by Uribe.

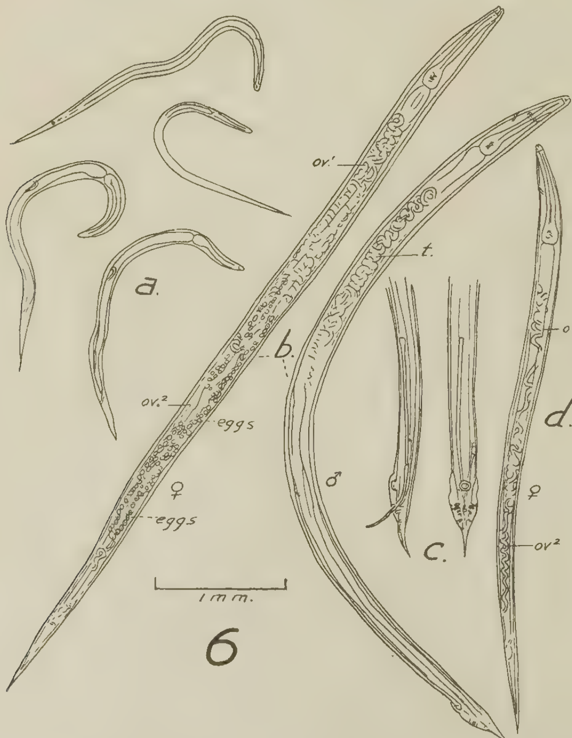


Figure 6. Examples of worms recovered on June 2nd, 1931, from chickens infested May 1st - 7th, 1931. (a) Representative specimens removed from chickens suffering from a severe blackhead infection. (b and c) Typical examples of worms from a bird which showed no signs of blackhead. (d) Common example of development of worms from birds showing some blackhead infection.

In other experiments with the caecal worm, pest-free chickens were infested with caecal worm egg material on July 6th, 1931. Figure 8 shows representative worms recovered from these birds when they were autopsied on August 4th, 1931. The size and development of these worms will be noted. They are undoubtedly mature worms and compare favorably in size with

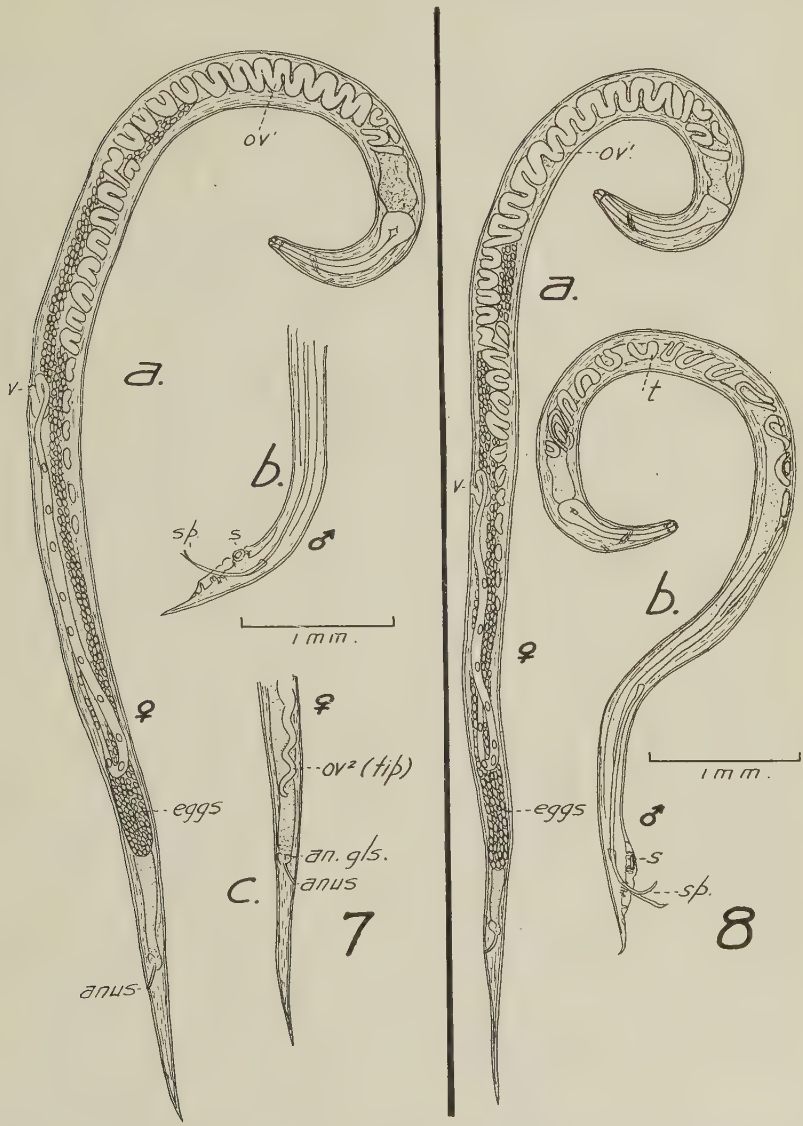


Figure 7. Examples of worms recovered from chickens 33-40 days after infestation. (a) Female, sinistral view. (b) Tail of male, sinistral view. (c) Tail of female, dextral view; *ov*¹, anterior ovary; *ov*², posterior ovary; *s*, sucker; *sp*, spicules; *an. gls*, anal glands; *v*, vulva.

Figure 8. Worms recovered on August 4th, 1931, from stock infested on July 6th, 1931. These worms are thus 29 days old and are clearly well developed mature worms. (Abbreviations as in Figure 7.)

those shown in Figure 7. These worms, however, are just 29 days old. At the time of infestation the birds used were pest free and 10 weeks of age.

Other experiments, carried out with baby chicks, gave similar results to the above in 1928. Pest-free chicks which were fed embryonated worm eggs on April 3rd, 1928, showed mature worms by May 3rd, 1928, i.e., in 30 days time. Worm eggs have been demonstrated in the faeces of infested birds after the 30th day.

From the writer's observations it appears that development of *Heterakis gallinae* is frequently completed in the chicken within a period of 30 days.

During the course of several experiments with *Heterakis gallinae* it was frequently observed that when blackhead infection became very marked that development of the caecal worm was checked rather markedly. The drawings in Figure 6a show worms recovered from birds showing a heavy blackhead infection in the caeca. The difference in development between these worms and those shown in Figure 6b is very marked, and yet no larger specimens than those illustrated were secured from the blackhead cases, and all the worms shown in Figure 6 were recovered on the same day from birds infested over the same period. The larger worms (Figure 6b) were recovered from birds that had shown no signs of blackhead infection. It is important to note that blackhead is quite common at this stage. Riley and James (*8*) found that the caeca of experimentally infested chicks showed marked inflammation and thickening of the walls. This change in the condition of the caeca has also been recorded from this institution (1929). In this connection the observations of Graybill (*5*) are particularly noteworthy wherein he makes the comment that "the abnormal condition of the ceca and their contents in cases that develop blackhead might have an unfavorable influence on the larvae." Uribe (*9*) also records blackhead outbreaks among his experimental birds.

If separate workers had followed through the rate of development of the worms shown in Figures 6a, 6b, and 6d, they would, very probably, have obtained vastly different figures for the time required for the worms to reach maturity. From the writer's observations and such support as is secured from the literature bearing on the subject, it appears evident that excessive development of blackhead in chickens tends to render conditions unsuitable for the rapid development of *Heterakis gallinae*. Some further support for this conclusion is lent by Graybill (*5*) where he observes that on the 14th day "a number of rather young larval stages were observed, a circumstance noted also on other occasions, indicating a considerable variation in the rate of growth."

The apparent close association of the blackhead agent and the caecal worm of fowls has resulted in the assumption that there is probably something in the nature of a symbiotic relationship existing between the two organisms. The facts seem to militate rather definitely against any such idea. Not only is the growth of the caecal worm checked, but the number of worms is usually considerably less in blackhead infested caeca than where the disease has not thoroughly established itself. While blackhead is not necessarily indicated as the sole factor which may retard development of *Heterakis gallinae*, it appears to exert an important influence. This influence also appears to be

sufficiently great enough in itself to enable us to explain many of the discordant results obtained by those who have studied the life cycle of this worm.

Summary

1. Studies of the development of *Heterakis papillosa* in the chicken in all probability refer to *Heterakis gallinae.*
2. A review of the literature shows that general agreement does not exist as to the time required for the caecal worm to complete its development within the chicken: results vary over a range of from 24 to 61 days.
3. Observations show that the development of *Heterakis gallinae* in the chicken is frequently completed within a 30-day period.
4. Observations made on the development of the caecal worm show general agreement with the recorded observations of other workers up until about the end of the second week of development of the worm larvae. The greatest differences usually become evident after the second week.
5. Blackhead frequently makes its appearance in chickens by the second and third weeks after ingestion of embryonated caecal worm egg material.
6. Caecal worms recovered from chickens badly infested with blackhead have been observed as being markedly checked in their development.
7. It appears evident that excessive development of blackhead in the caeca of chickens tends to render conditions rather unsuitable for the development of *Heterakis gallinae.*
8. While blackhead is not indicated as the only factor which may retard development of *Heterakis gallinae*, its influence appears sufficiently great enough in itself to enable us to explain the different findings obtained by those who have studied the life cycle of this worm.

Acknowledgements

The writer wishes to acknowledge many courtesies received from his associates, Prof. R. L. Conklin and Prof. W. A. Maw, with whom animal parasite studies were initiated and have been carried forward at Macdonald College.

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ON TREATING SEED POTATOES FOR THE CONTROL OF COMMON SCAB[1]

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For many years various disinfectants and fungicides have been used for the treatment of seed potatoes for the control of common scab, (*Actinomyces scabies* (Thaxter) Güssow), apparently in the firm belief that they are, directly or indirectly, effective for the purpose indicated. In fact many investigators have reported positive results, although some of these are indefinite.

From experience and extensive observations during the past five years the writer has been led to doubt whether thoroughly conclusive results may be obtained from these treatments under field conditions. Accordingly, critical studies were made in order to present a definite report on the value of a number of seed potato treatments commonly recommended for protection against scab. A part of the study was carried out under field conditions and a part in the laboratory. For convenience, each section will be dealt with separately.

It would seem unnecessary to present here a review of the immense literature concerning the control of potato scab by tuber treatment, for Hollrung (*2*) has recently given a fairly complete summary of it.

Field Studies

METHODS

For the field studies the following standard treatments were employed to disinfect the seed potatoes used: cold formaldehyde solution, 1-240 for 2 hours; hot formaldehyde, 1-120 for 3 minutes; mercuric chloride, 1-1000 for 2 hours; Bayer No. 649, 1 gr. dissolved in 67 cc. of water for 3 minutes, according to directions. In addition to these, the tests included: the planting of very scabby sets untreated; of treated sets, the surfaces of which had been coated with a virulent culture of *A. scabies* grown on nutrient agar; of treated sets, about each of which was placed a measured amount of a soil culture of the organism; and finally, of disinfected sets, in holes (15 inches in diameter and 5 inches deep) filled with a soil containing the actively growing pathogene. There were 8 different tests in the field experiment, each being replicated 6 times in short rows. Each row included 8 test hills and 8 check hills, the tests alternating with the check hills. Thus, each test involved a total of 48 hills with an equal number of check hills. The sets for the check hills were given the usual cold formaldehyde treatment.

The soil culture of *A. scabies* was prepared by sterilizing fertile black Edmonton loam, the moisture content of which was optimum, and then incorporating with this soil a spore suspension of the pathogene, grown on nutrient agar and incubated for one month. Tubers experimentally grown in a soil culture of this kind would be completely covered with scab, as was

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the case in this experiment. Potatoes of the Irish Cobbler variety were employed for the experiment. Only the most scabby tubers (see Figure 2) were used for determining the effect of planting scabby sets. The reaction of the soil was approximately pH 6.3.

At harvest, each hill was taken up so as to note the number of tubers and the distance at which they grew from the set, and whether the amount of scab on these was influenced by the treatment given the set. Each hill throughout the experiment was given an infection-rating that would indicate

TABLE 1.—*The relative amount of scab on tubers in relation to various treatments given the sets when planted.*

Treatment of Sets	Replicate	Infection % treatments* and checks†	Number tubers infected from sets
Formaldehyde, cold soak	1–6	9.8	
Check		10.0	
Formaldehyde, hot soak	1–6	10.0	
Check		10.2	
Mercuric chloride 1-1000	1–6	10.0	
Check		9.7	
Bayer No. 649	1–6	10.8	
Check		10.1	
Scabby untreated sets	1	10.4	0
	2	10.1	0
	3	10.0	0
	4	10.0	0
	5	10.7	0
	6	10.0	0
Check		10.1	
Coated‡ with spores of *A. scabies*	1	10.0	1
	2	11.4	3
	3	11.0	3
	4	10.3	0
	5	9.8	0
	6	10.7	1
Check		10.0	
Covered with soil inoculum of *A. scabies*¶	1	14.5	3
	2	16.0	3
	3	24.1	6
	4	15.0	4
	5	18.2	5
	6	11.4	1
Check		10.1	
Planted in hills of inoculated soil	1	100.	
	2	100.	
	3	100.	
	4	100.	
	5	100.	
	6	100.	
Check		10.1	

* In first four treatments averages are based on rating of 48 hills and on 8 hills in last four treatments.
† Infection rating of 48 hills for each treatment mentioned. Tubers disinfected in cold formaldehyde.
‡ Culture of *A. scabies* grown on potato dextrose agar.
¶ Pathogene increased in sterilized soil.

approximately the amount of scab. A value of 10 was given for a tuber which was completely covered with scab; 0.5 represented a trace; 1, slight; 2, light; 3 light +; 4 medium; 5, medium +; 6, severe, 7 severe +; 8, tuber surface ⅓ covered; 9, tuber surface ⅔ covered. The average infection rating for each treatment was thus determined. These data are found in Table 1, expressed in per cent.

RESULTS

The data in Table 1, concerning the use of cold formaldehyde, hot formaldehyde, mercuric chloride, and Bayer No. 649 soak treatments, readily suggest that there was no perceptible difference obtained from any of these disinfectants in reducing scab. The figures referring to these treatments represent the average infection rating for all of the six replicates of each test. In all cases the average infection rating was approximately 10% with monotonous regularity. If one compares these ratings with those of the potatoes from the untreated scabby sets, or with those of the check series, it is evident that no reduction of scab has been obtained by the various disinfectants mentioned. Obviously, the slight amount of scab that occurred came from the natural soil infestation. The uniformly slight amount of scab resulting from the soil infestation is shown in Figure 1, (c), (d) and (e).

In the treatment where the sets were heavily coated with a virulent culture of *A. scabies*, grown on nutrient agar, there was a slight increase of scab on only 8 tubers in the 6 replicates. The remarkable thing about this test is that a number of tubers which grew very near or almost against the coated sets were not affected by the inoculum put on the set. On the whole there was only a very slight effect from planting sets coated with the pathogene.

However, where the sets were covered with soil inoculum there was a definite increase in the amount of scab whenever the tubers grew near enough to the set to come into contact with the inoculum which surrounded it. These areas were always very scabby but definitely limited to the area of contact with the inoculum, (see Figure 1 (b)). However, it should be pointed out that although a number of tubers grew within an inch or less of the set, relatively few of these were near enough to the inoculum to become infected.

Practically all of the tubers from the hills where soil inoculum was used were covered with scab, as indicated in Figure 1 (a). Occasionally a tuber grew partly outside of the inoculated area, in which case only part of the tuber was very scabby. If the tuber grew entirely in the field soil, the amount of scab was very slight and characteristic of the infection from the normal soil infestation as indicated in Figure 1 (c), (d) and (e).

It is of interest to note the results obtained from coating the sets with the scab organism and from putting soil inoculum on the sets, because they show that the resulting crop ordinarily would not be infected unless the set carried a relatively great amount of the pathogene, and then only those tubers which grow in actual contact with the inoculum become very scabby. They also indicate that *A. scabies* does not grow any distance from the set into the soil, at least during the growing season.

Evidence in support of this was obtained by observing the size of single colonies of the pathogene growing in sterilized soil. Apparently a single spore of *A. scabies* usually forms a colony, the diameter of which is about 1.75 mm. under optimum temperature and moisture in sterile soil during four to eight weeks. In fact, the diameters usually vary from 1 to 1.5 mm. Figure 4 furnishes a good illustration of the average size of the colonies of the scab organism under optimum conditions. None of these exceeds 2 mm. in diameter.

Table 2 indicates the average number of scabby pustules per tuber for each treatment in replicate 3, which was representative. This count was made for the purpose of determining whether the numerical rating was relatively reliable. On account of the varying size of the scab pustules and their tendency to become confluent with each other, it is difficult to make an accurate count. Where the tubers were covered with scab, or were scabby in patches, a count was impossible, and the size of the scabby area is indicated. It will be observed that the results obtained by the count method, in the replicate chosen, agree closely with those obtained by the numerical infection rating given, and which have been presented in Table 1.

It may be added here, that the results just presented were obtained from a field test made during 1930. Practically identical results were also obtained from this experiment in 1928 and in 1929.

TABLE 2.—*The average number * of scab pustules per tuber resulting from various treatments of the set when planted.*

Treatment of sets	Number of tubers	Average pustules per tuber	Number of tubers infected from treatment on set
Formaldehyde, cold soak, 1-240	31	13.0	0
Check	34	13.5	
Formaldehyde, hot soak, 1-120	35	12.9	0
Check	41	13.4	
Mercuric chloride solution, 1-1000	32	13.6	0
Check	35	12.5	
Bayer No. 649, soak	38	13.3	0
Check	34	13.0	
Scabby untreated sets	39	13.0	0
Check	40	13.3	
Coated with spores of *A. scabies*	33	15.1	3, slightly
Check	42	13.3	
Covered with soil inoculum of *A. scabies*	40	27.6+	6, 1/9 to ½ of surface scabby
Check	31	12.8	
Planted in hills of inoculated soil	38	covered	all†
Check	43	13.2	

* The pustules were counted, except where an area was covered with scab, such area being indicated by a plus sign.

† Occasionally a tuber grew more or less out of bounds of the soil inoculum and was not entirely covered with scab. (See figure 1 (a)).

Laboratory Studies

These studies represent an attempt to demonstrate how close *A. scabies* will grow to potato tissue which is treated with some of the disinfectants and compounds recommended for treating seed potatoes. For this purpose the treated potato tissue was placed in sterilized soil inoculated with the pathogene. The tests were made in 1-litre glass flasks so that the growth of the organism in the soil could be observed. Sterilized Edmonton black loam (pH 6.3), adjusted to optimum moisture content, was employed. Cylindrical pieces of potato tissue 4 mm. in diameter, and 8 mm. long were cut from potato tubers and treated as follows: hot formaldehyde, 1-120 parts water at 125° F. for 5 minutes; cold formaldehyde, 1-240 parts water for 2 hours; mercuric chloride, 1-1000 parts water for 2 hours; Bayer dust No. 649, 1 gr. in 67 cc. water for 1 hour. Moist sterile potato cores were rolled in the following dusts: Bayer No. 649, Semesan Bel, and flowers of sulphur, respectively. The treated potato cores were laid at suitable intervals on the inoculated soil so that the ends of the cores were directly against the glass. Sterile, untreated cores were placed alternately with the treated ones. More inoculated soil was then added and the cultures incubated at 23° C. for 14 days. These tests were repeated 4 times. The effect of the treatment was determined by observation and it was measured 7 days after planting and again 7 days later. The results have been so constant that the data obtained from the final test is presented as being representative for all tests made.

Table 3.—*The growth of A. scabies in sterilized soil in relation to various disinfectants and fungicides on potato tissue.*

Treatment* of Moist Potato Core	Average distance in millimeters between core and growth of *A. scabies* after treatment	
	7 days	14 days
A. Formaldehyde, cold soak 1-240 cc. water for 2 hours	0	0
Check	0	0
B. Mercuric chloride soak 1-1000 cc. water for 2 hours	0	0
Check	0	0
C. Bayer No. 649 soak 1 gr. in 67 cc. water for 1 hour	2	1
Check	0	0
D. Bayer dust No. 649, thickly coated	3	1
Check	0	0
E. Semesan Bel, thickly coated	0	0
Check	0	0
F. Sulphur, thickly coated	0	0
Check	0	0
G. Formaldehyde, hot soak, 1-120 cc. water at 125°F for 5 min.	3	0
Check	0	0

* Each "treatment" involved 6 cores, 3 of which were treated. The cores were planted under aseptic conditions, immediately after treatment.

The Relative Effect of Various Treatments on *A. scabies* in Sterilized Soil

The effects of the disinfectants and fungicides used in the laboratory study on *A. scabies* in the soil are summarized in Table 3.

At the end of 3 days a marked growth of the pathogene appeared in a ring-like formation about all of the potato cores, apparently being stimulated by the cores themselves. This growth was uniformly as close to the cores treated with cold formaldehyde and mercuric chloride solutions, and Semesan Bel and Sulphur dusts, as it was to the cores which received no treatment. In the case of the Bayer No. 649 compound, the ring growth formed approximately 3 mm. from the treated cores, the distance being slightly greater where the cores were covered with thick paste than where they were soaked. Photographs (C) and (D) in Figure 3, taken at the end of 7 days, indicate the initial retarding effect on *A. scabies* of Bayer No. 649. Apparently the gas from the hot formaldehyde treatment also exercised a definite retarding effect at first, but before 14 days had passed the pathogene grew vigorously, close to the core. The retarding effect was more permanent in the case of the Bayer dust and soak treatments, for apparently the pathogene did not grow closer than 1 mm. to the core. It should be mentioned here that the cores were planted immediately after being treated.

Considering all the treatments it is obvious that, in the last analysis, the protective effect of any of them did not extend much, if at all, beyond the cores themselves. The application of this fact in connection with treating seed potato sets in field practice will be dealt with later. In practice, potato sets would not be so heavily coated with the dusts as were these cores. It should also be mentioned that the cores treated with Bayer No. 649 solution were soaked for 1 hour instead of from 3 to 5 minutes as recommended by the manufacturers.

The Relative Amount of Pathogene Carried on the Surface of Stored Tubers

An attempt was made to determine the relative amount of *Actinomyces* sp. which a very scabby tuber usually carries. Accordingly, a number of scabby tubers, all approximately as scabby as the potato shown in Figure 2, were selected at harvest and stored in a root cellar under cool and relatively humid conditions. At intervals, from harvest to 6 months afterwards, dilution cultures were made from the surface of each tuber and also from the pulverized scab tissue of each potato. The surface of each of 47 scabby potatoes was washed separately in a litre of sterile water. The "wash" from each tuber was then diluted 1-10,000 and 1-100,000. One cubic centimeter was transferred from each dilution to plates and cultured in the usual manner in potato dextrose agar. After the tubers were washed the scab pustules were scraped off, dried for a short time, but sufficiently to pulverize into a fine dust, then diluted and cultured as before. The spores could not have been killed by the drying process. In the case of 10 other scabby tubers, the surface wash and the pulverized scab pustules were diluted together and cultured. Ample time was given for colonies of actinomycetes to appear in the plates before a count was made. Thus dilutions were made from 57 scabby tubers. the average size of which was 16.5 × 15.3 × 8.2 centimeters. Six cultures

were made from each dilution, so that the final results are based on a total of 1128 plates.

The data, which are briefly summarized in Table 4, show that only seven colonies of *Actinomyces* sp. appeared from all the cultures made. These results were contrary to what was expected. The materials were repeatedly tested and found to be very favorable for the rapid growth of *A. scabies.* Evidently the spores or vegetative parts of the actinomycetes which may have been carried by these very scabby tubers were not sufficiently abundant to be revealed by the technique used. However, these surprising results would at least indicate that the very scabby specimens used carried less spores than the amount of actinomycetes usually carried by a gram of field soil and which amount may be revealed by the method employed. Further study on this is needed before a final conclusion can be made.

TABLE 4.—*Number of colonies of Actinomyces sp. obtained from very scabby potatoes*.*

Treatment	Number tubers treated	Total colonies from dilutions	
		1-10,000	1-100,000
Surface wash	47	1	0
Pulverized scab pustules	47	2	1
Surface wash and pulverized scab pustules	10	2	1

* Average size of scabby tubers used 15.3 X 16.5 X 8.4 centimetres.

DISCUSSION

The information which has been presented in Tables 1, 2, 3 and 4 lends itself in several ways for discussion in connection with the practical value of treating potatoes against common scab. But before proceeding it may be well to emphasize that the primary object of this study was to demonstrate the effect of disinfecting tubers in reducing scab on the resulting crop. Crop rotation and other conditions which may affect the development and the amount of the scab organism in the soil itself are of secondary consideration at present.

The results of the field study presented in Table 1 show that the disinfectants commonly recommended for the control of potato scab produced no perceptible decrease in the amount of this disease on the new crop. These treatments included soaking the seed in solutions of cold formaldehyde, hot formaldehyde, mercuric chloride, and Bayer preparation No. 649. Further, the planting of very scabby untreated sets did not cause any apparent increase of scab on the resulting crop. Also, when sets were rubbed with a pure culture of the pathogene there was practically no increase of scab on the new

Explanation of Figures 1 and 2 on opposite page.

Figure 1. Typical hills of potatoes from field experiment illustrating the relative amount of scab resulting from various treatments given the sets. (a) sets planted in a hill of soil inoculum; (b) sets covered with soil inoculum; (c) sets marked with a virulent culture of *A. scabies*, (d) very scabby sets untreated; (e) check; sets disinfected with cold formaldehyde.

Figure 2. A tuber typical of the scabby potatoes from which scabby sets were obtained for the field experiment.

Figure 1. See foot of opposite page for explanation.

Figure 2. See foot of opposite page for explanation.

crop. When the set was covered with a soil culture of the pathogene a definite increase of scab appeared only on a few tubers which happened to grow in the inoculated soil immediately about the set. And, inasmuch as these field studies were repeated three seasons under favourable conditions with practically identical results, as given for the final test in Table 1, it is felt that similar data may be obtained as often as the experiment is repeated.

The results of the laboratory test given in Table 2 explain why the disinfecting of tubers cannot be expected to control scab on the new crop. Hot or cold formaldehyde, mercuric chloride and Bayer No. 649 used as soak treatments, and Bayer No. 649, Semesan Bel and sulphur used as dust treatments were not materially active in controlling *A. scabies* beyond the set itself, as shown by the fact that the pathogene grew close up to the treated tissue in all cases. This would also occur under field conditions. Thus it is reasonable to conclude that the amount of scab on the new crop would depend wholly on the natural infestation of the soil and not on the pathogene which may be on the scabby set. Moreover, the evidence was that the growth of this pathogene, whether it developes from the scab or from spores on the surface of the set, is very definitely restricted to a small area and cannot spread far of itself. The evidence in Figure 4 and measurements taken show that during 60 days colonies of *A. scabies* growing in the sterilized soil rarely exceeded 2 mm. in diameter. Moreover, the writer has never yet observed *A. scabies* grow from potato tissue in a moist sterile soil more than 2 mm. during three months. It is not likely that this organism would grow more actively in natural soil where it is exposed to competition with micro-organisms and to other conditions of soil and temperature. Only those tubers of the new crop close against the old scabby set would be near enough for infection. The only possible value, then, of the treatment would be confined to the destruction of the pathogene on the surface of the tuber or within the scab lesions.

Viable spores or other parts of the pathogene on the surface of the set or in the scab pustules have been looked upon with apprehension as a possible means of producing scab on the new crop and also of increasing the organism in the soil. The first fear would seem to be groundless, as indicated by the data just supplied. Earlier references to the futility of treatment to control scab were made by Sanford (*5*) in 1925 and by Remy (*4*) in 1928.

With regard to the second possibility, there does not appear to be definite evidence available that the pathogene grows forth again from the old pustule under field conditions and, if so, whether growth is sufficient to augment the soil infestation beyond that which would normally take place. The corky debris of the pustule harbours a large number of common bacteria and fungi of the soil, many of which may be antagonistic to *A. scabies* in pure culture, as indicated by Sanford (*6*). If moisture conditions were favorable for growth of the micro-organisms, especially as the set decays, it seems quite possible that *A. scabies* would grow very little, if at all. As for such growth augmenting the natural soil infestation of the scab pathogene, we know practically nothing at present. Perhaps antagonistic factors, such as are concerned with the association of the micro-organisms already present, the food and the moisture supply, are sufficient to maintain a certain biological balance regardless of the possible addition of new spores of *A. scabies*.

Few, if any, normal virgin soils appear to be free from *A. scabies*. This has been pointed out previously by Lutman (*3*) and also by Sanford (*7*). If the soils were free there would be an argument for treating seed potatoes. But this does not appear to be the case, and many instances could be cited where a potato crop on newly broken virgin soil, and without any known source of contamination, has been fairly scabby and at times very scabby. Bedford (*1*) obtained a fairly high count of *Actinomyces* sp. in certain virgin prairie soils of Alberta. Also it is common, in Alberta at least, that the virgin soil once broken up may soon become sufficiently infested with the scab organism to produce very scabby potatoes, apparently regardless of the crop history. Obviously, the point of interest here is whether the slight amount of inoculum that may be added on contaminated seed will make any practical difference to the increase of the natural soil infestation. This question has a practical significance concerning the value of seed treatment and it is also of academic interest to soil micro-biology. Other questions are also raised concerning the actual effect of crop sequence in reducing scab, but about which very little definite information appears to be available.

Summary

1. A comparison has been made of the efficiency of certain disinfectants and fungicides, which are commonly recommended, for treating seed potatoes to prevent common scab caused by *A. scabies*.
2. Hot formaldehyde, cold formaldehyde, mercuric chloride or Bayer No. 649, used as soak treatments, produced no perceptible effect in reducing common scab on the resulting crop in field culture.
3. In sterilized soil of optimum moisture content *A. scabies* grew vigorously and practically in contact with cores of potatoes treated with hot formaldehyde, cold formaldehyde, mercuric chloride or Bayer No. 649 solutions as with those coated with sulphur, Semesan Bel or Bayer No. 649 dusts.
4. The planting of untreated scabby sets did not increase the amount of scab on the resulting crop.
5. When sets were coated with a virulent culture of *A. scabies* only a slight amount of scab appeared on the new crop and then only on a few of the tubers which grew close against the old inoculated set.
6. When sets were planted in soil culture of *A. scabies*, only that part of any tuber which grew in the inoculated soil area was covered by scab.
7. It is concluded that the methods now recommended for disinfecting seed potatoes to reduce common scab on the resulting crop are of no practical value under ordinary field conditions.
8. It is also contended that the relative efficiency of one tuber treatment over another cannot be demonstrated under ordinary field conditions.

Explanation of Figures 3 and 4 on opposite page.

Figure 3. The growth of *A. scabies* in sterilized soil in relation to various disinfectants and fungicides on potato tissue. (A) formaldehyde, cold soak, 1-240 for two hours. (B) mercuric chloride soak, 1-1000 for two hours. (C) Bayer No. 649 soak, 1 gram in 67 cc. water for one hour. (D) Bayer 649 dust, thickly coated. (E) Semesan Bel dust, thickly coated. (F) sulphur dust, thickly coated. The "X" signs indicate untreated cores.

Figure 4. Single colonies of *A. scabies* growing in a sterilized soil medium.

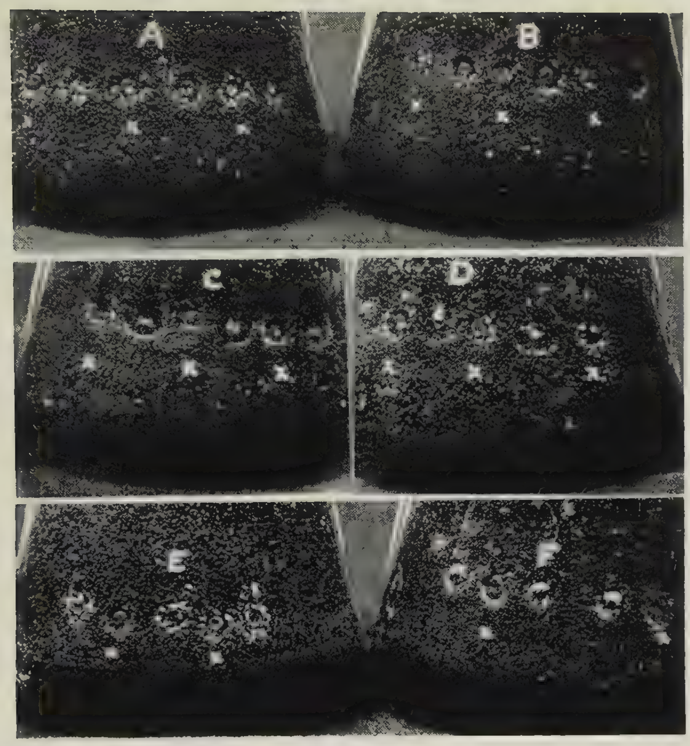

Figure 3. See foot of opposite page for explanation.

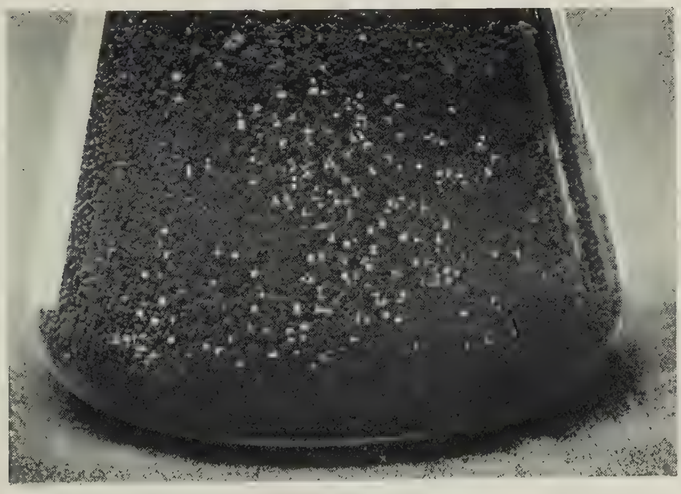

Figure 4. See foot of opposite page for explanation.

9. The question is raised whether the amount of the scab pathogene in the soil is augmented by the planting of scabby, untreated, potato sets beyond the increase which normally occurs.

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CURRENT PUBLICATIONS

"SMUTTY" WHEAT CAUSED BY *USTILAGO UTRICULOSA* ON DOCK LEAVED PERSICARY. O. S. Aamodt and J. G. Malloch. Canadian Journal of Research, Vol. 7, No. 6. December, 1932.

Ustilago utriculosa (Nees) is reported for the first time in Canada on pale of dock-leaved persicary. It is a loose smut readily dispersed when passing through a threshing machine.

Infected persicary plants growing in a wheat field were harvested with the grain, and in the threshing operation the grain was mechanically contaminated with smut spores. The grain was visibly covered with smut, but there was no odor as is the case when wheat is infested with bunt spores.

Wheat contaminated with persicary loose smut spores seems to be subject to the usual additional cost in handling common to "smutty" wheat caused by bunt. The effect of persicary smut on the loaf color was similar to that of bunt. These observations afford an example of the indirect ways in which weeds may cause losses in crop production.

VITAMIN A AND D STUDIES WITH GROWING CHICKS

A Comparison of Cod Liver Oil and Pilchard Oil as Sources of the Growth Promoting Factor Vitamin A

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[Received for publication June 5, 1932]

In work recently published by the author (*1*) it was demonstrated that oil produced from the pilchard (*Sardina caerulea*) of the British Columbia coast, and cod liver oil were equally efficient in the production of normal bone development and in ability to prevent rickets in chicks. It was also determined that the pilchard oil was unable to support normal growth when fed as a supplement to a ration otherwise devoid of substances containing vitamin A. In the light of these facts it appeared to be important to obtain more data on the comparative value of these oils for growth production as well as for bone formation.

Historical

A general bibliography of previous work with fish liver and body oils pertinent to the subject matter of this paper was given in the previous publication by the author to which reference has already been made. Comparatively few reports have been published upon the vitamin A content of fish oils. Holmes and Pigott (*2*) and Brocklesby (*3*) found the liver oil of the dogfish to be a potent source of vitamin A. Cruickshank, Hart and Halpin (*4*) investigating the vitamin content of cod liver meal found a relatively high concentration of vitamin D but a decided deficiency of vitamin A. Davis and Beach (*5*) and Nelson and Manning (*6*) found salmon oil to be as potent as cod liver oil in vitamin A. The last mentioned authors also found tuna and sardine oils to be relatively low in vitamin A content. Drummond and Hilditch (*7*) determined the comparative potency of liver oils of numerous fishes in addition to many samples of different cod liver oils for vitamin A. In most cases a content fairly comparable to the cod liver oil used was found. Of the above mentioned tests those of Cruickshank *et al* (*4*) and Davis and Beach (*5*) were carried out upon chickens as experimental animals, whereas rats were used in the remainder. The tests with chickens were based upon prevention of vitamin A deficiency while in all other tests mentioned the curative method was employed.

Experimental

In determining the value of any substance as a source of vitamin A two entirely different methods of procedure are generally accepted. In the one, and most commonly used with rats, the experimental animals are carried upon a ration devoid of the vitamin until such time as their body supply of the vitamin is used up and growth entirely ceases or until marked symptoms of ophthalmia are evident. The substance under test is then fed and the vitamin A rating of the supplement is determined by the amount necessary to cure the ophthalmia if present or to induce normal growth. The other

[1] Poultry Husbandman.

method is to feed the substance the potency of which is to be determined from the commencement of the test gauging its effectiveness by its ability to prevent the ophthalmic condition and to produce normal growth. Past experience and observation at this Division has indicated that where chicks were used as the experimental animals, data of much greater reliability would be obtained by the preventive method. The results of this experiment bear out past observation in this regard.

Barred Plymouth Rock chicks were used in this test and were divided as evenly as possible into six pens of twenty four chicks each. They were kept in a battery brooder in which temperature and all other external conditions are readily controllable.

The arrangement of the pens and the treatment accorded the chicks is shown in Table 1.

TABLE 1.—*Treatment of chicks.*

Pen No.	Ration	Supplement	Daily irradiation
1	Basal	1% pilchard oil	10 minutes
2	Basal	1% cod liver oil	10 minutes
3	Basal	Control pen	20 minutes
4	Basal	2% pilchard oil	10 minutes
5	Basal	2% cod liver oil	10 minutes
6	Standard	1% cod liver oil	10 minutes

The basal ration fed was considered to be vitamin A free (or approximately so) and was composed of the following ingredients: bran 15%, wheat middlings 30%; ground oats 28%; white corn meal 10%; bone meal 2% and skim milk powder 15%.

At two weeks of age 30% of ground oat groats was added to this ration since the consistency of the ration due apparently to its high fibre content and the fineness of the skim milk powder upset the digestion of the birds. They returned to normal immediately after this change was made and before growth was seriously retarded.

The standard ration as given to pen 6 was one which had previously given excellent growth under identical conditions and was as follows:—wheat

TABLE 2.—*Percentage composition of rations.*

Ration	Moisture	Crude Protein	Fat	Carbo-hydrates	Fibre	Ash
Basal	6.93	18.07	5.83	59.61	4.93	4.63
Standard	6.44	19.56	7.55	53.79	5.13	5.53

shorts, wheat middlings, yellow corn meal and ground oat groats 22% of each; meat meal 6%; fish meal, buttermilk powder and bone meal 2% of each. To this mixture 1% of poultry cod liver oil was added. The analyses of these rations are given in Table 2.

One mixing only of the basal and standard rations was made so that each pen received the same mixture throughout the test.

It might be mentioned that the analysis of the standard ration showed originally only 3.14% of fibre but was made to equal the basal ration in this respect by the addition of pure paper pulp having a very high pure cellulose content. It will be noted that the standard ration was higher in protein (1.49%) and fat (1.72%) and lower in carbohydrates (5.82%). These slight differences were unavoidable and would not ordinarily influence growth appreciably. No grain or green feed was fed at any time but limestone grit was scattered over the mash occasionally.

The pilchard oil used was obtained from pilchard caught upon the west coast of Vancouver island and was a composite sample carefully taken from each of eight tanks representing the seasons catch for 1931 of a large Pacific coast concern. The sample was a composite from oil dipped from the centre of each tank above the stearin which had settled in each instance.

The cod liver oil used was a Newfoundland poultry oil such as has been used at this poultry plant for some time past and was fairly typical of the better grade of cod liver oils for poultry feeding purposes.

The data in Table 3 are indicative of certain characteristics of these oils.

TABLE 3.—*Composition of cod liver oils used.*

Sample	Free fatty acids as oleic	Vitamin A content
Pilchard oil	0.66%	2.20 (Lovibond blue units in 10cc soln.)
Cod Liver Oil	3.69	8.0 " " "

The reliability of the above test for vitamin A has already been referred to in a previous paper. (*1*). The pilchard oil used, although merely commercial run, is much lower in free fatty acid content than the cod liver oil.

Since it was highly desirable that the variation in the level of vitamin D of these oils should have no effect upon the results the chicks of all pens were irradiated daily with the mercury vapour lamp at a distance of three feet from the subjects. Since it was previously shown that both the cod liver oil and pilchard oil were well supplied with vitamin D it was considered that ten minutes daily was sufficient for the pens using these supplements as against twenty minutes, the most normal period of irradiation as indicated by previous work at this Division (*8*), for the control pen which received no oil.

The experiment covered a period of seven weeks with a short additional period for a curative test on birds suffering from vitamin deficiency.

Results

As was mentioned previously owing to the consistency of the basal ration the birds in pens one to five became slightly unthrifty during the second week but quickly returned to normal when the difficulty was corrected. This slight setback is noticeable in the growth curves shown herewith. With this exception the condition of the chicks was quite good throughout in all but pen 3, and that of pen 6 on the standard ration was exceptionally good. These birds averaged 535 grams in weight at seven weeks of age with a high degree of uniformity. Figure 1 indicates the growth and feed consumption of each pen for weekly periods.

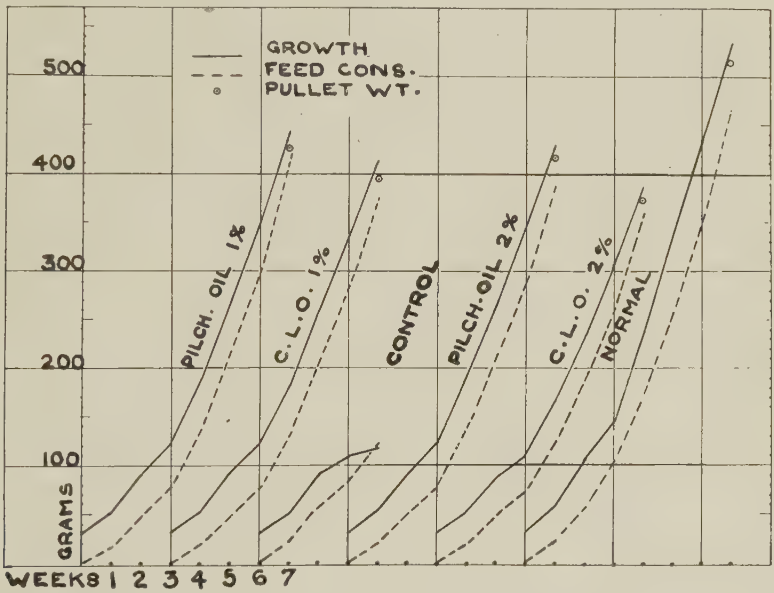

Figure 1. Growth and feed consumption of each pen for weekly periods. The pullet weight of all pens was 92.00 ± .498% of cockerel weight at seven weeks of age. The cockerels were reduced to their pullet equivalent weight upon this basis, the average thus obtained being indicated for each pen on the chart. Feed consumption as indicated is one third of actual in order to accommodate the figures to the chart.

The chicks in pen 3 which received the vitamin A free ration with no supplement, except ultra violet irradiation to supply vitamin D, made growth approximately equal to the other pens until the end of the second week at which time growth slowed down somewhat as indicated by the growth curve in Figure 1. At three weeks of age two chicks were off their feet and many others showed staggering gait and loss of balance. Tremors were also noticeable in some instances. At four weeks of age this pen had to be removed from the test to save heavy mortality. Even at this stage there was some growth response, and some chicks showed little if any evidence of deficiency. Neither symptoms nor lesions of ophthalmia were evident, loss of balance and staggering gait being the principle indications of deficiency, a condition also found by other investigators notably Cruickshank *et al* (*4*) and Capper, McKibbin and Prentice (*9*).

Chicks from all pens were autopsied and in no instance was any marked departure from the normal indicated in any pen, not excepting the control, pen 3. No indications of typical vitamin A deficiency conditions were found even in this pen either as a condition of visceral gout with a deposit of urates in the organs, or abnormalities such as fibrinous deposits in the eyes or respiratory passages indicative of ophthalmia. It has previously been pointed out by investigators, notably Capper *et al* (*9*) that a condition of visceral gout as described above is sometimes found in cases of vitamin A deficiency. The lack of definite post-mortem symptoms of visceral gout, that is the deposition of urates, may be explained by the observation of Cruickshanks *et al* (*4*) to the effect that this condition obviously developed immediately prior to dea'h from vitamin A deficiency causes and was not present a short time previously. Since the birds used for autopsy purposes from this pen were killed in the advanced stages rather than allowed to die as a result of the deficiency, the non-development of the condition may thus be explained.

Reference to Figure 1 shows that the birds on the standard ration made considerably greater gains than those on any other treatment. Also pilchard oil gave greater growth at both 1% and 2% levels than did comparable levels of cod liver oil. It is further interesting to note that the rations containing the lower percentage of oil gave superior growth to the rations containing the higher percentage, a result which has consistently been the case in previous work at this Division. Feed consumption varied fairly well in proportion to the growth attained.

Discussion

Since considerable variation will normally occur between weights of individuals in the pens it is essential to know whether this variation might not be so great as to overshadow the differences between the pens, which are small in some instances. Consequently the data were statistically treated, the measurements obtained being set forth in Tables 4 and 5 following. These data were calculated on pullet equivalent weight for all pens.

Table 4.—*Statistical significance of variations between pens.*

Pen	Supplement	Mean Weight	Standard Deviation	Coefficient of variability
1	1% pilchard oil	426.0 ± 6.17	39.80 ± 4.36	9.36%
2	1% cod liver oil	395.4 ± 12.13	76.26 ± 8.57	19.29
4	2% pilchard oil	421.5 ± 11.72	77.74 ± 8.29	18.44
5	2% cod liver oil	374.3 ± 12.69	86.30 ± 8.98	23.06
6	Standard 1% cod liver oil	516.4 ± 6.75	45.76 ± 4.76	8.86

It is interesting to note that uniformity as indicated by the coefficient of variability is in the order of pen 6 and pen 1 and also that these pens gave the greatest as well as the most uniform growth. The probable errors are relatively small in all instances.

In order to determine whether the differences between the final weights of the pens were of significance the probable error of the difference and the odds were calculated.

TABLE 5.—*Statistical significance of differences between final weights of pens.*

Pens	Difference of means	P. E. of Difference	Odds against the difference being due to chance
1 : 2	30.68 ± 13.61	2.25	6.73 : 1
2 : 5	47.25 ± 17.27	2.74	14.77 : 1
1 : 6	90.36 ± 9.14	9.89	65 billion to 1.

As indicated by the data in Table 5 the odds against the difference in body weight between pens 1 and 2 (1% pilchard oil and 1% cod liver oil) being due to chance rather than to fundamental differences in the nutrition of the pens are only 6.73 to 1. For 2% levels of these oils the odds again are only 14.77 to 1. This being the case it must be considered that no significant difference existed between these pens. The odds against the difference between pens 1 and 6 being due to chance are 65 billion to 1, odds which are highly significant. In other words the apparent differences between the growth produced by pilchard oil and cod liver oil in this test are of little if any significance with a suggestion of a small measure of significance only where 2% levels are considered. The differences between the growth produced by the standard ration and all other rations used, however, are highly significant.

In considering these results it is necessary to determine that variation in vitamin A content is essentially the factor responsible for the differences in growth obtained. The determination of this fact depends upon the correctness of choice of the basal ration and whether it was deficient in vitamin A and in no other factor in so far as this can be determined in the light of our present knowledge of poultry requirements.

In the first place it may be taken for granted that the addition of pilchard oil and cod liver oil contributed no essential nutrient, not otherwise supplied, but merely vitamins A and D if, and to the extent, present. Since by daily irradiation the control pen (pen 3) on the basal ration received the D equivalent factor to a sufficient extent to assure normal growth and bone development, the factor of vitamin D deficiency may be dropped from the consideration. In addition the deficiency symptoms of this pen were not in the slightest suggestive of a rachitic condition. Upon macrosopic examination the bones of these chicks appeared to be normal.

While the calcium-phosphorous ratio cannot be calculated, owing to the fact that limestone grit was fed *ad lib* at regular intervals, it may be pointed out that the skim milk powder, bone meal and limestone grit (containing 92% pure calcium carbonate) supplied a sufficient amount of calcium and phosphorous. In addition, the fact that plentiful irradiation was given would ensure the ability to use the minerals present. Further the pens receiving

the oil supplements received the same minerals as the control pen but showed no symptoms of deficiency.

The vitamin B complex of which vitamin B_1 is without doubt of greatest moment where poultry are concerned was supplied to the extent that it was present in the cereal grains which made up the greatest portion of the ration.

Plimmer, Raymond and Lowndes (*10*) determined that the following levels of the different cereal grains are necessary to supply sufficient vitamin B_1 for the maintenance of normal condition in the pigeon; wheat 40%, bran 20%, wheat middlings 10%, wheat germ 7%, oats 40%, corn 50% and marmite 6%. That is, if any one of the above cereals or by-products is present to the extent indicated a sufficiency of B_1 will be supplied to the ration. The basal ration under consideration contained 11.5% of bran, 23% of middlings or a total of 34.5% of wheat products; 44.5% of ground oats of which more than half was without hulls and consequently proportionably higher in B_1 and 7.7% of white corn meal. This being the case there is no reasonable doubt but that a sufficiency of this vitamin was present in the ration.

In all respects then, other than vitamin A the rations fed to the control pen and the pens receiving pilchard and cod liver oils, with the exception only of the normal pen, were equal. As a consequence the lack of growth and deficiency symptoms evidenced must have been directly or indirectly due to the absence of this vitamin.

The survivors of pen 3 were divided into two equal lots receiving the same basal ration. Each lot received four drops of pilchard oil by mouth daily and one lot had an addition of 4% of yeast incorporated into their mash. Most of the chicks in the advanced stages of vitamin A deficiency did not respond to treatment and died shortly after its commencement. Some which had shown only slight signs of deficiency also failed to respond while the remainder slowly returned to normal condition. This irregularity of response is in itself indicative of the degree of unreliability which might be experienced in using the curative method in assaying vitamin A potency, where chicks are the experimental animals.

In considering the data recorded it is apparent then that when a ration devoid of, or very low in, vitamin A content was fed to chicks, growth response was slightly lowered and extreme symptoms of deficiency became evident. The addition of pilchard oil or cod liver oil to such a ration increased growth and prevented the appearance of these symptoms.

Summary

1. The addition of pilchard oil or cod liver oil to a ration otherwise deficient in vitamin A increased growth and prevented the development of deficiency symptoms in chicks.
2. Neither pilchard oil nor cod liver oil, however, when fed with this deficient ration at levels of 1% and 2% of the total feed consumed supplied sufficient of vitamin A to bring about as rapid growth as was attained by a pen on a well balanced ration.
3. It would appear from the data obtained that pilchard oil and cod liver oil were of equal value in so far as vitamin A content is concerned with a suggestion that pilchard oil was slightly more efficient in this respect.

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CURRENT PUBLICATIONS

TYPES OF TUBERCLE BACILLI IN HUMAN TUBERCULOSIS. R. M. Price. Canadian Journal of Research, Vol. 7, No. 6, December, 1932.

Four hundred and thirty-six cases of clinical tuberculosis were investigated with a view to ascertaining the types of the infecting organism. In this series of cases, 268 were children under 14 years of age, and 168 adults, 15 years and over. Both medical and surgical cases were studied. In the juvenile group, 230 patients proved to be infected with the human type, and 38, or 14.1%, with the bovine type of the tubercle bacillus. In the adult group 6, or 3.5%, proved to be infected with the bovine type, the remaining 162 cases with the human type of the tubercle bacillus. Bovine tuberculosis in man is milk-borne and preventable.

STUDIES ON VIM OAT FEED

I. The Digestibility of Vim Oat Feed

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[Received for publication November 3, 1932]

Introduction

Vim Oat Feed is the proprietary name of a by-product obtained in the milling of rolled oats. It is defined by the Feeding Stuffs Act as follows:—

> "Oat Feed consists of offal obtained in the milling of rolled oats from clean oats, and containing less than 28 per cent of fibre. It must include not less than the mill-run of oat middlings and not more than the mill-run of oat hulls."

Obviously it consists largely of oat hulls but contains also such outer portions and fragments of the oat groat as are scoured off in removing the hull. Since Oat Feed contains materials other than hulls it has received this classification in the Feeding Stuffs Act separate and distinct from that of oat hulls.

Table 1.—*Chemical composition of Vim Oat Feed in per cent.*

	Lot I	Lot II	Lot III
Moisture	8.20	6.36	5.92
Ash	5.98	5.97	5.81
Protein (N x 6.25)	4.20	3.96	3.82
Ether Extract	1.33	1.74	1.76
Crude Fibre	26.90	28.15	30.55
Nitrogen Free Extract	53.39	55.82	52.14

The chemical compositions of three lots of Vim Oat Feed, analyzed in this laboratory, are given in Table 1. According to this table Vim Oat Feed is essentially a carbohydrate feed. Whatever value, therefore, it may possess will depend largely upon the degree to which its carbohydrates are utilized by the animal body. Such utilization can only be estimated from a study of the digestibility of Vim Oat Feed together with properly controlled feeding trials. This is being accomplished in the present instance by undertaking the following three investigations:—

(1) Studies on the digestibility of Vim Oat Feed.

(2) Studies on the value of Vim Oat Feed in fattening rations for steers, using the paired feeding method of experimentation.

[1] Chemist, Division of Chemistry. The senior author wishes to express his acknowledgment to Dr. Frank T. Shutt, Dominion Chemist, for his generous support and helpful criticism during the progesss of this investigation.
[2] Acting Dominion Animal Husbandman.
[3] Assistant in Chemistry.

(3) Studies on the value of Vim Oat Feed in dairy cattle rations, using the double reversal group system of experimentation.

The present paper deals only with the first of these investigations, namely, studies on the digestibility of Vim Oat Feed. The results of the other two investigations will be published at a later date.

Experimental

The digestibility of a feeding stuff of the nature of Vim Oat Feed is generally determined in combination with a basal ration of known digestibility. Errors in coefficients of digestibility so determined may arise from one or all of the following considerations:—

(1) The effect of "association" when individual feeds are compounded into a ration.

(2) The effect of a varying plane of nutrition.

(3) The effect of variation among individual animals.

(4) The effect of environmental and physiological conditions, including all errors which are inherent to work of this nature.

(5) The magnitude of the ratio of the quantity of nutrients in the basal ration to the quantity in the feed under examination.

The present investigation has, accordingly, been planned with a view to eliminating or minimizing as far as possible the effects of these probable sources of error. To do this the experiments have been carried out in the following order:—

(1) A determination of the coefficients of a basal ration when fed to four animals at a constant level of intake.

(2) A determination of the coefficients of digestibility of a basal ration when fed to four animals at different levels of intake.

(3) A determination of the coefficients of digestibility of a mixture of Vim Oat Feed with the basal ration.

(4) A determination of the coefficients of digestibility of Vim Oat Feed when fed alone.

Six steers were used in this investigation, numbered as follows: 60627E, 60629E, 60630E, 60631E, 84387J, and 84381J. The digestion trials consisted of a preliminary feeding period of ten days followed by a collection period varying in length, according to the experiment, of from twelve to twenty days. The collection period was divided into sub-periods of four days each. During each of these sub-periods the feeds and excrements were composited and analyzed. The results of the digestion trials are reported in the following experiments.

Experiment AN-1. Individual Variation in Coefficients of Digestibility

The coefficients of digestibility of a ration of mixed clover and grass hay were determined in quadruplicate, using animals 60627E, 60629E, 60630E, and 60631E. Each of the four animals received sixteen pounds of hay per day, together with one ounce of iodized salt.

The necessary data for calculating the coefficients are given in Table 12 in the appendix. A summary of the coefficients is given in Table 2. Although only four samples are available, estimates of the coefficients of variability and of the standard errors of the means of the groups have been included.

TABLE 2.—*Individual variation in coefficients of digestibility of a mixed clover and grass hay.*

	Animal 60627E	Animal 60629E	Animal 60630E	Animal 60631E	Mean	Coefficient of Variability	Standard Error of Mean
Ration (lbs.)	16	16	16	16			
Dry Matter	57.6	58.8	58.8	59.2	58.6	1.18	±0.35
Organic Matter	58.9	60.2	60.1	60.4	59.9	1.13	±0.34
Nitrogen	63.0	63.7	64.6	64.3	63.9	1.11	±0.35
Ether Extract	54.5	56.3	54.2	56.1	55.3	1.95	±0.54
Crude Fibre	53.4	54.4	53.9	53.9	53.9	0.76	±0.20
Nitrogen Free Extract	61.5	63.7	63.6	63.6	63.1	1.69	±0.53

An examination of the above table reveals the fact that the agreement among the individual animals is reasonably close. There is, therefore, no reason to suspect abnormality on the part of any of the animals.

EXPERIMENT AN-2. RELATION OF PLANE OF NUTRITION TO DIGESTIBILITY

The coefficients of digestibility of the basal ration employed in Experiment AN-1 were re-determined when the hay was fed at the following levels:—

Animal No.	*Lbs. hay per day*
60627E	19
60629E	14
60630E	12
60631E	10

One ounce of iodized salt was included in each daily ration.

TABLE 3.—*Coefficients of digestibility of mixed hay when fed at different planes of nutrition.*

	Animal 60627E	Animal 60629E	Animal 60630E	Animal 60631E	Mean	Coefficient of Variability	Standard Error of Mean
Ration (lbs.)	19	14	12	10			
Dry Matter	60.6	60.3	60.6	59.1	60.1	1.19	±0.36
Organic Matter	62.3	61.9	62.3	60.6	61.8	1.31	±0.40
Nitrogen	63.6	63.1	63.2	61.7	62.9	1.32	±0.41
Ether Extract	56.6	55.9	55.0	51.2	54.7	4.40	±1.20
Crude Fibre	56.2	56.3	56.7	54.4	55.9	1.83	±0.51
Nitrogen Free Extract	66.1	65.4	66.2	65.0	65.7	0.87	±0.29

The necessary data for the calculation of the coefficients of digestibility are given in Table 13 in the appendix. A summary of the coefficients is given in Table 3.

From this summary it may be observed that the coefficients of digestibility of each nutrient of the hay as determined with animals 60627E, 60629E, and 60630E agreed very closely with one another. On the other hand, the coefficients as determined with the fourth animal were slightly lower. The deviation is, nevertheless, of the same order as that in Table 2. In this latter case it will be seen as formerly that the coefficients of digestibility as determined with three of the animals, namely, 60629E, 60630E, and 60631E showed a close agreement with one another, whereas the coefficients as determined with the fourth animal 60627E were lower. There is, therefore, no indication that the plane of nutrition *per se* has influenced the coefficients of digestibility of the roughage.

Certain points of interest, however, deserve to be remarked. In the first place, this present experiment does not include extreme planes of nutrition of either sub-maintenance or super-maintenance. At such levels physiological factors may act to modify the coefficients. Again, in considering the results of experiment AN-1, the assumption was made that the variations among the individual animals were a result of normal experimental errors. This assumption could only be proved or disproved by several repetitions — an undertaking which was beyond the scope of this investigation.

Finally, the results obtained in these experiments with a roughage only must not be confused with those obtained when the ration consists of a roughage and a concentrate. Mitchell (*2*), for instance, reports on the effect of the plane of nutrition upon digestibility when a ration of 10 kg. of corn, 3 kg. of alfalfa hay, 250 g. of linseed meal, and 116 g. molasses was fed to an animal at the following planes of nutrition: full-feed, four-fifths feed, three-fifths feed, two-fifths feed, and one-fifth feed. He concluded that "the lowest level of feeding was associated with the most complete digestibility of all nutrients. However, there was a progressive decrease in digestibility from the lowest to the highest ration only in the case of nitrogen-free extract, ether extract, and dry substance." These increases in digestibility at the lowest level of feeding were, apparently, associated with an increased fermentation of carbohydrates in the digestive tract of the animal. The dry substance of the ration used by Mitchell contained over 85% of carbohydrates. Any change, therefore, in the intensity of the fermentation processes would exert a large influence upon the coefficient of digestibility of the dry substance. It is to be remarked, in this regard, that the crude protein, amounting to slightly over 10% of the dry matter, showed no consistent change in digestibility. It would seem, therefore, that for the present, any statement of the relationship existing between the level of feeding of a ration and its digestibility must be limited to certain specific experimental conditions.

For the purpose, therefore, of later determining the coefficients of digestibility of Vim Oat Feed, the eight coefficients of digestibility for each nutrient (of the mixed hay) were assumed to belong to the same population and the variations noted were assumed to be of the order of the natural errors inherent

in investigatory work of this nature. Accordingly, for the coefficients of digestibility of the basal ration, the results of all the determinations have been averaged. These averages are given in Table 4.

Table 4.—*Average coefficients of digestibility of basal ration.*

Constituent	Mean Coefficient of Digestibility*	Coefficient of Variability	Standard Error of Mean
Dry Matter	59.4	1.77	±0.37
Organic Matter	60.8	2.00	±0.43
Nitrogen	63.4	1.41	±0.32
Ether Extract	55.0	3.20	±0.62
Crude Fibre	54.9	2.35	±0.46
Nitrogen Free Extract	64.4	2.47	±0.56

* Estimated from eight samples.

Experiment AN-3. Coefficients of Digestibility of a Ration of Mixed Hay and Vim Oat Feed.

The coefficients of digestibility of a mixture of the basal ration and Vim Oat Feed were determined when the two constituents were fed in the following amounts:—

Animal	*Lbs. hay per day*	*Lbs. Vim per day*
60627E	12	10
60629E	12	10
60630E	12	5
60631E	12	5

One ounce of iodized salt was added to each daily ration.

The necessary data for calculating the coefficients of digestibility of the mixed ration and of the Vim Oat Feed are given in Table 14 in the appendix. A summary of the coefficients of digestibility of the mixed ration is given in Table 5, and of the calculated coefficients of Vim Oat Feed in Table 6.

Table 5.—*Coefficients of digestibility of a mixed ration of hay and Vim Oat Feed.*

	Animal 60627E	Animal 60629E	Average	Animal 60630E	Animal 60631E	Average
Dry Matter	43.6	45.4	44.5	49.2	48.9	49.1
Organic Matter	44.8	46.6	45.7	50.6	50.0	50.3
Nitrogen	60.9	61.7	61.3	61.7	62.0	61.9
Ether Extract	45.5	41.0	43.3	39.7	39.4	39.6
Crude Fibre	38.7	41.1	39.9	45.4	44.9	45.2
Nitrogen Free Extract	44.7	46.9	45.8	51.6	50.5	51.1

TABLE 6.—*Calculated coefficients of digestibility of Vim Oat Feed.*

	Animal 60627E	Animal 60629E	Animal 60630E	Animal 60631E	Mean	Coefficient of Variability	Standard Error of Mean
Dry Matter	24.9	28.9	25.1	24.0	25.7	8.45	±1.09
Organic Matter	26.1	30.0	26.9	24.8	27.0	8.19	±1.11
Nitrogen	51.5	55.4	49.2	51.9	52.0	4.92	±1.28
Ether Extract*	28.3	15.6	—	—	—	—	—
Crude Fibre	16.2	21.8	18.7	16.8	18.4	13.7	±1.26
Nitrogen Free Extract	28.7	32.7	30.8	27.9	30.0	7.21	±1.08

* Owing to the small quantity of ether extract in the Vim Oat Feed it was not possible to obtain satis factory calculated coefficients.

EXPERIMENT AN-7. COEFFICIENTS OF DIGESTIBILITY OF VIM OAT FEED WHEN FED ALONE

Concurrently with the above experiments, the coefficients of digestibility of Vim Oat Feed were determined when this feeding stuff was fed alone to two steers—numbers 84387J and 84381J. The collection period was shortened to twelve days. The Vim Oat Feed was fed at a level of 15 pounds per animal per day. One ounce of iodized salt was included in the daily rations.

The necessary data for calculating the coefficients of digestibility are given in Table 15 in the appendix. A summary of the coefficients is given in Table 7.

TABLE 7.—*Coefficients of digestibility of Vim Oat Feed.*

	Animal 84387J	Animal 84381J	Average
Dry Matter	33.5	33.5	33.5
Organic Matter	34.5	35.2	34.9
Nitrogen	45.7	40.3	43.0
Ether Extract	66.3	66.2	66.6
Crude Fibre	32.7	33.5	33.1
Nitrogen Free Extract	33.2	34.3	33.7

From a comparison of Tables 6 and 7, it will be observed that the coefficients of digestibility obtained when Vim Oat Feed was fed alone are, in certain respects, appreciably different from those calculated from a mixture of the Vim Oat Feed with hay. It must be noted that the animals used in Experiment AN-7 were not the same as those used in Experiment AN-3. In so far, therefore, as the large variations observed between the two sets of data could be due entirely to individuality, the assumption of a significance in this difference would be false. In view, however, of the results of Experi-

ments AN-1 and AN-2, and in view of the fact that all the animals were of the same type, the possibility that individuality alone was the cause of this difference seems remote. The differences can then, be provisionally ascribed to the effect of "association."

From an inspection of the coefficients of the individual nutrients certain assumptions concerning the specific cause of the effect of "association" can be made. For instance, a comparison of Tables 6 and 7 shows that the digestibility of the nitrogen free extract was of the same order in both experiments, though probably slightly lower in Experiment AN-3 than in Experiment AN-7. The crude fibre was, however, digested to a much greater extent in Experiment AN-7 than in Experiment AN-3. This is reflected, of course, in the results for the dry matter and the organic matter, which are mostly carbohydrate in nature.

The differences in the digestibility of the crude fibre are probably related to a difference in the degree of fermentation of this substance in the two experiments. Results of other experiments at this laboratory in connection with investigations upon Biological Values and "Associative" Digestibility have emphasized the important role played by the fermentation processes in modifying the digestibility of a ration.

The digestibility of the nitrogen may or may not follow that of the fibre, depending upon what changes may be expected in the "metabolic" nitrogen and bacterial nitrogen of the feces. With these two factors remaining constant, increased utilization of the fibre should bring about an increased liberation and digestion of the protein.

The differences in the coefficients of nitrogen in these experiments are, however, more probably related to the question of the "metabolic" nitrogen of the feces. In this connection, Titus (*4*) has illustrated a mathematical relationship between the digestibility of protein and the moisture content of the feces. While it might be more logical to state that a difference in moisture content is indicative of a difference in the digestive processes, nevertheless, the net result is qualitatively, the same. In Table 8 is given a summary of the moisture content of the feces in the various experiments.

It will be noted that when the Vim Oat Feed was fed alone the feces were quite dry. When it was fed in connection with the hay, the moisture of the

TABLE 8.—*Moisture content of the feces in per cent.*

Animal No.	Exp. AN-1	Exp. AN-2	Exp. AN-3	Exp. AN-7
60627E	86.11	86.58	76.84	
60629E	82.40	82.71	73.30	
60630E	84.65	84.42	77.97	
60631E	85.16	84.60	79.17	
84387J				61.80
84381J				68.60

feces was lower than when hay alone constituted the ration. In so far then, as the quantity of "metabolic" nitrogen in the feces is associated with the variations in the moisture content, the coefficient of digestibility of the nitrogen of Vim Oat Feed as determined in Experiment AN-3 may be different from that determined in Experiment AN-7.

The effect of "association" upon digestibility may then be provisionally related to at least two factors, namely, changes induced in the ratio of the "metabolic" nitrogen to the dry matter consumed, and changes in the activity of the fermentation processes in the digestive tract.

Such conclusions presuppose that the coefficients have been determined with a relatively high degree of accuracy. Otherwise, false assumptions would be made. This is particularly true where the amount of any one nutrient in one feed is much greater than the amount of the same nutrient in the other feed. In the present case, for example, an experimental error of 3% in the determination of the nitrogen of the feces in Experiment AN-3 would greatly change the calculated coefficient for Vim Oat Feed. The criterion for accuracy is the agreement among the four calculated coefficients determined for two different ratios of hay to Vim Oat Feed. The coefficients as calculated in this experiment could preferably have been in closer agreement. In the case of crude fibre, however, owing to the high percentage in Vim Oat Feed, the results are reasonably definite.

In assessing the value of Vim Oat Feed, therefore, from an examination of its coefficients, attention must be given both to the digestibility of the Vim itself, and to the digestibility calculated from a mixed ration.

The Feeding Value of Vim Oat Feed

In order to appreciate the significance of the data presented in the preceding experiments, a comparison has been made in Table 9 between the digestibility of the nutrients in Vim Oat Feed and those of some common feeding stuffs. The values for timothy and oat straw were taken from other investigations in this laboratory, and those for oats and wheat bran from a compilation by Fraps (*1*).

Table 9.—*Comparison of coefficients of digestibility of Vim Oat Feed with those of some common feeds.*

	Vim Oat Feed from Exp. AN-3	Vim Oat Feed from Exp. AN-7	Mixed Hay	Timothy	Oat Straw	Oats	Wheat Bran
Dry Matter	25.7	33.5	59.4	54.4	50.2		
Organic Matter	27.0	34.9	60.8	55.6	52.2		
Nitrogen	52.0	43.0	63.4	40.7	40.9	79.26	82.58
Ether Extract	22.0*	66.6	55.0	52.9	35.8	89.66	84.06
Crude Fibre	18.4	33.1	54.9	55.0	52.3	59.63	44.05
Nitrogen Free Extract	30.0	33.7	64.4	57.6	54.7	84.45	80.27

* Average of coefficients of animals 60627E and 60629E.

From an examination of this table it may be observed that the nutrients of Vim Oat Feed have a comparatively low digestibility. This low digestibility is intensified when the Vim Oat Feed is incorporated into mixed rations.

Comparing feeds upon the basis of their total digestible nutrients does not take into consideration the difference in value between the protein and the carbohydrate part of the ration. Allowing for this difference, Petersen (*3*) has recently evolved a method for evaluating feeds on the basis of their content of digestible protein and digestible carbohydrates. This has been applied to the assessment of the value of Vim Oat Feed. Taking the market prices of barley and oil meal as basal, the comparative values of Vim Oat Feed and of some common feeds have been calculated according to the formulae of Petersen. The results are expressed in Table 10.

TABLE 10.—*Values of Vim Oat Feed and some common feeds as compared with barley and oil meal.**

Feed	Value when Barley is $23.00 Oil Meal is $32.00	Value when Barley is $23.00 Oil Meal is $42.00
Vim Oat Feed from Exp. AN-3	$ 7.23	$ 6.88
Vim Oat Feed from Exp. AN-7	8.37	7.45
Oat Straw	12.23	11.16
Oats	21.15	21.96
Wheat Bran	20.11	22.73
Timothy	13.07	11.32
Mixed Hay	12.82	12.25

* Table compiled by J. G. Stothart, Division of Animal Husbandry.

According to this table, Vim Oat Feed is given a value of less than one-half the value of bran or oats, and about three-quarters of the value of timothy, straw, or mixed hay. It is realized, of course, that this method of comparing feeds makes the tacit assumption that equal weights of protein in different feeds will be of equal value for maintenance and production, and similarly for the non-protein fraction of the ration. This is not necessarily true. Nevertheless, this method presents a simple means of comparing feeds upon the basis of their digestible nutrients. From this standpoint alone Vim Oat Feed must be considered as a feed of relatively low value.

Whether or not Vim Oat Feed possesses some specific value not revealed by a comparison of its chemical composition and digestibility, when incorporated in a mixed ration, can only be determined by properly controlled feeding trials. As mentioned previously, this investigation is being continued along these lines and the results will be reported at a later date.

CONCLUSIONS

1. For roughages only, the plane of nutrition, within certain limits, did not markedly influence the coefficients of digestibility.

2. The coefficients of digestibility of Vim Oat Feed were low compared to those of other common feeds such as mixed hay, timothy hay, and oat straw.

3. When Vim Oat Feed was mixed with a roughage, the digestibility of the crude fibre of the total ration was markedly lower than that expected from a consideration of the digestibilities of that nutrient in hay alone and in Vim Oat Feed alone.

4. Upon the basis of its content of digestible nutrients, Vim Oat Feed possesses a calculated feeding value of less than one-half of the value of bran or oats and about three-quarters of the value of mixed hay, timothy hay or straw.

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Appendix

Table 11.—*Composition of feeds in per cent.*

	Hay Experiment AN-1	Hay Experiment AN-2	Hay Experiment AN-3	Vim Oat Feed Experiment AN-3	Vim Oat Feed Experiment AN-7
Moisture	8.01	7.79	9.77	8.20	5.92
Ash	7.32	7.30	7.50	5.98	5.81
Protein	12.83	12.64	13.35	4.20	3.82
Ether Extract	2.67	2.49	2.01	1.33	1.76
Crude Fibre	32.96	30.21	31.25	26.90	30.55
Nitrogen Free Extract	36.22	39.58	36.12	53.39	52.14

Table 12.—*Calculation of coefficients of digestibility for experiment AN-1. Weights in kilogrammes. Collection period of 16 days.*

	Animal 60627E	Animal 60629E	Animal 60630E	Animal 60631E
1. *Dry Matter*				
In feed	106.830	106.830	106.830	106.830
In feces	45.326	43.996	43.967	43.550
Digested	61.504	62.834	62.863	63.280
Coefficient	57.6	58.8	58.8	59.2
2. *Organic Matter*				
In feed	98.320	98.320	98.320	98.320
In feces	40.419	39.099	39.183	38.949
Digested	57.901	59.221	59.137	59.371
Coefficient	58.9	60.2	60.1	60.4

Table 12.—*Continued.*

	Animal 60627E	Animal 60629E	Animal 60630E	Animal 60631E
3. *Nitrogen*				
In feed	2.384	2.384	2.384	2.384
In feces	0.884	0.865	0.843	0.851
Digested	1.500	1.519	1.541	1.533
Coefficient	63.0	63.7	64.6	64.3
4. *Ether Extract*				
In feed	3.100	3.100	3.100	3.100
In feces	1.411	1.356	1.421	1.360
Digested	1.689	1.744	1.679	1.740
Coefficient	54.5	56.3	54.2	56.1
5. *Crude Fibre*				
In feed	38.274	38.274	38.274	38.274
In feces	17.838	17.460	17.648	17.633
Digested	20.436	20.814	20.626	20.641
Coefficient	53.4	54.4	53.9	53.9
6. *Nitrogen Free Extract*				
In feed	42.059	42.059	42.059	42.059
In feces	16.174	15.281	15.308	15.323
Digested	25.885	26.778	26.751	26.736
Coefficient	61.5	63.7	63.6	63.6

Table 13.—*Calculation of coefficients of digestibility for experiment AN-2. Weights in kilogrammes. Collection period of 16 days.*

	Animal 60627E	Animal 60629E	Animal 60630E	Animal 60631E
1. *Dry Matter*				
In feed	127.150	93.690	80.306	66.920
In feces	50.050	37.309	31.646	27.404
Digested	77.100	56.381	48.660	39.516
Coefficient	60.6	60.2	60.6	59.1
2. *Organic Matter*				
In feed	117.080	86.272	73.948	61.623
In feces	44.152	32.901	27.867	24.272
Digested	72.928	53.371	46.081	37.351
Coefficient	62.3	61.9	62.3	60.6
3. *Nitrogen*				
In feed	2.787	2.053	1.760	1.467
In feces	1.014	0.758	0.647	0.562
Digested	1.773	1.295	1.113	0.905
Coefficient	63.6	63.1	63.2	61.7
4. *Ether Extract*				
In feed	3.434	2.530	2.169	1.807
In feces	1.492	1.116	0.976	0.882
Digested	1.942	1.414	1.193	0.925
Coefficient	56.6	55.9	55.0	51.2
5. *Crude Fibre*				
In feed	41.656	30.694	26.310	21.922
In feces	18.253	13.425	11.398	10.005
Digested	23.403	17.269	14.912	11.917
Coefficient	56.2	56.3	56.7	54.4
6. *Nitrogen Free Extract*				
In feed	54.578	40.215	34.471	28.725
In feces	18.493	13.918	11.650	10.062
Digested	36.085	26.297	22.821	18.663
Coefficient	66.1	65.4	66.2	65.0

TABLE 14.—*Calculations of coefficients of digestibility for experiment AN-3. Weights in kilogrammes. Collection period of 20 days.*

	Animal 60627E	Animal 60629E	Animal 60630E	Animal 60631E
1. *Dry Matter*				
In hay	98.226	98.226	98.226	98.226
In Vim	83.280	83.280	41.640	41.640
Total ingested	181.506	181.506	139.866	139.866
In feces	102.398	99.039	71.058	71.512
Digested	79.108	82.467	68.808	68.354
Coefficient	43.6	45.4	49.2	48.9
Digested from hay	58.347	58.347	58.347	58.347
Digested from Vim	20.761	24.120	10.461	10.007
Coefficient of Vim	24.9	28.9	25.1	24.0
2. *Organic Matter*				
In hay	90.062	90.062	90.062	90.062
In Vim	77.855	77.855	38.927	38.927
Total ingested	167.917	167.917	128.989	128.989
In feces	92.761	89.735	63.694	64.499
Digested	75.156	78.182	65.295	64.490
Coefficient	44.8	46.6	50.6	50.0
Digested from Hay	54.848	54.848	54.848	54.848
Digested from Vim	20.308	23.334	10.447	9.642
Coefficient of Vim	26.1	30.0	26.9	24.8
3. *Nitrogen*				
In hay	2.325	2.325	2.325	1.395*
In Vim	0.610	0.610	0.305	0.183*
Total ingested	2.935	2.935	2.684	1.578*
In feces	1.147	1.123	1.006	0.599*
Digested	1.788	1.812	1.625	0.979*
Coefficient	60.9	61.7	61.7	62.0*
Digested from hay	1.474	1.474	1.474	0.884*
Digested from Vim	0.314	0.338	0.150	0.095*
Coefficient of Vim	51.5	55.4	49.2	51.9*
4. *Crude Fibre*				
In hay	34.020	34.020	34.020	34.020
In Vim	24.403	24.403	12.202	12.202
Total ingested	58.423	58.423	46.222	46.222
In feces	35.789	34.432	25.263	25.489
Digested	22.634	23.991	20.959	20.733
Coefficient	38.7	41.1	45.4	44.9
Digested from hay	18.677	18.677	18.677	18.677
Digested from Vim	3.957	5.313	2.282	2.066
Coefficient of Vim	16.2	21.8	18.7	16.9
5. *Ether Extract*				
In hay	2.188	2.188	2.188	2.188
In Vim	1.207	1.207	0.603	0.603
Total ingested	3.395	3.395	2.791	2.791
In feces	1.849	2.003	1.684	1.691
Digested	1.546	1.392	1.107	1.100
Coefficient	45.5	41.0	39.7	39.4
Digested from hay	1.204	1.204	1.204	1.204
Digested from Vim	0.342	0.188	—	—
Coefficient of Vim	28.3	15.6	—	—
6. *Nitrogen Free Extract*				
In hay	39.322	39.322	39.322	39.322
In Vim	48.436	48.436	24.218	24.218
Total ingested	87.758	87.758	63.540	63.540
In feces	48.541	46.621	30.762	31.465
Digested	39.217	41.137	32.778	32.075
Coefficient	44.7	46.9	51.6	50.5
Digested from hay	25.323	25.323	25.323	25.323
Digested from Vim	13.894	15.814	7.455	6.752
Coefficient of Vim	28.7	32.7	30.8	27.9

* Based on collection period of twelve days.

Table 15.—*Calculations of coefficients of digestibility for exeprime‍nt AN-7. Weights in kilogrammes. Collection period of 12 days.*

	Animal 84387J	Animal 84381J
1. *Dry Matter*		
In Vim Oat Feed	76.814	76.814
In feces	51.060	51.060
Digested	25.754	25.754
Coefficient	33.5	33.5
2. *Organic Matter*		
In Vim Oat Feed	72.061	72.061
In feces	47.230	46.691
Digested	24.831	25.370
Coefficient	34.5	35.2
3. *Nitrogen*		
In Vim Oat Feed	0.499	0.499
In feces	0.271	0.298
Digested	0.228	0.201
Coefficient	45.7	40.3
4. *Ether Extract*		
In Vim Oat Feed	1.437	1.437
In feces	0.484	0.476
Digested	0.953	0.961
Coefficient	66.3	66.9
5. *Crude Fibre*		
In Vim Oat Feed	24.943	24.943
In feces	16.797	16.596
Digested	8.146	8.347
Coefficient	32.7	33.5
6. *Nitrogen Free Extract*		
In Vim Oat Feed	42.563	42.563
In feces	28.444	27.966
Digested	14.119	14.597
Coefficient	33.2	34.3

RECENT FINDINGS IN TRACTOR ENGINE LUBRICATION[1]

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The internal combustion engine of today is vastly more refined than the engine of ten years ago. There is very little difference in the tractor, combine, truck, and automobile engines as far as lubrication requirements are concerned. Today the tractor, combine and truck engines have given place to the 50, 75, 90 and even 200 H.P. automobile engine as far as horse power and severity of operation is concerned.

Lubrication Systems

A study of the lubrication systems indicates that the external force feed oil pump and distribution is a thing of the past and that all of the tractor, combine, truck and automobile engines are built with the crank case system of lubrication. It also indicates that the proportion of tractors using the different crank case systems of lubrication is quite in keeping with that of the automobile.

Splash Circulation Lubrication. There are only a few of the tractors equipped with the splash circulation lubrication system. The system consists of an oil pump in the crank case, which delivers the oil to the main bearings and dip pans for the connecting rods, and in some engines to the valve operating mechanisms. The pistons and cylinders are lubricated from the oil mist produced by the splash from the connecting rods passing through the oil in the dip pans.

Pressure Mist Lubrication. Most tractors, almost all of the combine motors and a large number of truck motors, are designed with the pressure mist system of lubrication. The pressure mist system of lubrication consists of an oil pump located in the crank case which delivers oil under pressure to the main bearings and cam shaft bearings, through the drilled crank shaft to the connecting rod bearings and in some engines to the valve operating mechanisms. The cylinders and pistons are lubricated from the oil mist thrown from the connecting rod bearings. In some engines the connecting rods are fitted with small oil orifices which member with the pressure passages of the crank shaft once each revolution. The oil spraying from the orifices tends to insure a saturated oil mist in the crank case.

Full Pressure Lubrication. The full pressure lubrication system consists of an oil pump located in the crank case, so that oil is drawn from the sump and delivered to the cam shaft bearings and main bearings, through the drilled crank shaft to the connecting rods up through the drilled rods to the wrist pins. There may be oil orifices located on the connecting rods for the purpose of producing a saturated oil mist in the crank case for lubricating the pistons and cylinders. The oil may also be delivered to the valve operating mechanisms from the pump.

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[1] Paper read before the Agricultural Engineering Group of the C.S.T.A. at the Manitoba Agricultural College, Winnipeg, June 15, 1932.

[2] Professor of Agricultural Engineering.

It is well to note that the three systems differ somewhat in the method of lubricating the bearings, the pressure systems becoming more positive, but that the cylinders and pistons are lubricated by an oil mist in all of the systems.

Oil Filters

Oil filters of three general types are found in series with the distribution system and the oil pump in many of the lubrication systems. The oil filter is undoubtedly of value in separating carbon and dirt from the oil as it passes on to the working parts of the engine. The oil filters should be carefully serviced as recommended, so that the oil may be conditioned as best possible by the filter. The cloth cartridge should be replaced whenever the cotton covering becomes too thin.

Lubricating Oils

The function of the lubricating oil is to provide a film between the working parts of the engine at all times, under any conditions of operation and at any temperature.

Properties of a Lubricant. The properties of a good lubricant may be listed as follows:

(a) Maximum degree of fluidity with sufficient body to prevent its being squeezed from between the bearing surfaces thereby giving a minimum total fluid and solid friction.

(b) Low surface tension toward the metals it is to lubricate.

(c) Freedom from injurious acids and alkalis with respect to the substances with which it comes in contact.

(d) High thermal capacity to enable it to carry off the heat of friction and combustion without excessive rise in temperature.

(e) Freedom from oxidation and decomposition in service.

(f) High temperature of vaporization.

(g) Low temperature of congelation.

(h) Freedom from solids that may score the bearings or obstruct the distribution system.

Tests for Oils. There have been two general reasons for testing oils. One, to fix or specify a particular oil which has been found suitable in practice, so that subsequent deliveries shall be similar, while the other has been to determine the suitability of an oil for a given purpose. There is some doubt as to the possibility of successfully accomplishing either of these aims. However, with increasing technical knowledge these doubts are being rapidly overcome. A great amount of very valuable research is being done by the Society of Automotive Engineers on engine lubrication. They have realized the many difficulties of the problem and have co-operated with the petroleum industry in this work. The S.A.E. classification of all lubricating oils is only one of the results of their work.

S.A.E. Classification. Engineers have recognized the possibility of selecting the proper grades of a lubricating oil by using viscosity as a gauge

resulting in a classification of oils by the Society of Automotive Engineers as S.A.E. numbers. The following are the S.A.E. classifications:

	Saybolt Standard Viscosity at			
	130°F		210°F	
	Min.	Max.	Min.	Max.
S.A.E. No. 10	90	less than 120		
20	120	" " 185		
30	185	" " 255		
40	255			less than 75
50			75	" " 105
60			105	" " 125
70			125	" " 150

The S.A.E. classification of oils has contributed materially to a uniform interpretation of the physical properties of lubricating oils.

Specific Gravity. The specific gravity of an oil is the ratio of the weight of a given volume of the oil to that of an equal volume of water. The specific gravity bears no simple relation to any other physical property of an oil. Broadly speaking, the oils of low specific gravity possess viscosities which are not affected by temperature to so great an extent as oils of high specific gravity. Very roughly, the specific gravity gives a hint as to the shape of the viscosity temperature curve.

Flash and Fire Points. The flash point of an oil is the temperature at which sufficient vapor is produced to give a mildly explosive mixture with air. The Cleveland open cup is the standard method for obtaining the flash point in the United States and Canada, as adopted by the American Petroleum Institute, and the American Society for Testing Materials. The flash point is not a measure of the volatility of the oil, because it usually represents the vapor pressure of the most volatile constituent of the oil which may only be a minute fraction of the total. It does not measure the ability of the oil to resist decomposition by heat and is in no way related to the carbonizing or oxidising tendencies of the oil. Generally speaking, a reasonable flash point is some indication of a well refined oil.

The fire point is determined by heating the oil to a still higher temperature, where sufficient vapor is given off to continue combustion for at least five seconds after being ignited by the test flame.

Viscosity. Viscosity is a definite physical property of a liquid, which is essentially the resistance which the particles of the liquid offer to a force tending to move them relatively. The American standard and the A.P.I. standard for determining viscosity of an oil of more than 32 seconds at 210°F is by the use of the Saybolt Universal Viscosimeter. The temperatures at which the oil is tested are 100°, 130° and 210°F. The Society of Automotive Engineers have suggested 130°F and 210°F while the manufacturers have used 100°F and 210°F.

An intensive study of the effect of temperature upon viscosity has revealed many characteristics of oils. The characteristics have been plotted on cross section paper for years, where all points have been determined experimentally. During the course of the study by the Lubricants Division

of the American Society of Automotive Engineer's Standards Committee, Larson (*5*) developed a simplified chart for plotting the viscosity temperature curves. The plotting paper is so designed that only two or more points are necessary after which a straight line placed upon the paper through the points, indicates quite accurately the viscosity temperature characteristics of the oil for all operating temperatures.

Cold Test. The behavior of oil under conditions of extreme cold is of practical importance. Oils do not solidify suddenly, but gradually thicken as the cold increases to a point where the oil becomes opaque. This temperature is called the "cloud point". On still further cooling the temperature is reached at which the oil becomes frozen solid, and this is called the cold test or "setting point". The "pour point" is approximately 5°F above the setting point. The pour point is that point at which oil will just cease to flow when a vessel containing it is tilted for five seconds. This point is of chief practical interest when studying engine lubrication in cold weather.

Selection of Oils for Engines. A few years ago oils were classified as automobile oils and tractor oils. The automobile oil was the light oil and the tractor oil the heavy. Today the tractor and the automobile use the same oil. The automobile is, if anything, a more powerful engine operating at higher speeds and temperatures than the tractor engine. The S.A.E. classification has eliminated all such distinction and rightly so.

There are paraffin and naphthene base oils, also blends of the two and process oils where animal or vegetable oils are compounded with the mineral oil. They are all classified according to their viscosity temperature characteristics as applied to the engine. Contamination by dirt, water and carbon tends to effect the lubrication more than the base characteristics of the oil.

Engine Wear. A study of engine wear today reveals excessive wear of the cylinders, pistons and rings, which tends to indicate that the oil is not being properly distributed or conditioned during service. There seems to be no difference in the system of lubrication or distribution as far as performance is concerned, since in all of the crank case systems the pistons and cylinders are lubricated by an oil mist produced in the crank case.

Indications are that too heavy oils are being used, which results in inadequate distribution to the pistons and cylinders resulting in excessive wear.

Day (*4*) indicates when making a lubrication analysis of typical internal combustion engines used in the tractor, combine, truck and automobile engines that oils of any viscosity between 44 and 50 seconds Saybolt at 210°F are considered satisfactory for the lubrication of the cylinders and pistons, also that the bearing requirements call for an oil possessing a viscosity of 42 seconds or higher at 210° F. He also states that for racing engines, using pressure-feed lubrication, an oil of approximately 42 seconds Saybolt at 210°F gave superior speed and suitable protection to the engine when compared with oils of 50 seconds Saybolt at 210°F.

Larson (*5*) states that an oil should not be lighter than 60 seconds Saybolt at the operating temperature of the engine. He also states that difficulty in starting the automobile is experienced if the viscosity for starting is more than 50,000 seconds Saybolt.

The maximum oil temperature for tractors operating on rated load which we have been able to obtain, varies from 140°F to 180°F, depending upon the volume of oil in the crank case and the area of crank case exposed. The maximum crank case oil temperature that I have been able to obtain in my Chevrolet engine operating at 45 miles an hour, where the outside temperature was above 100°F, was 196°F. According to Ramsaur (7) crank case oil temperatures increase nearly in proportion to the power and speed of the engine, ranging as follows:

Engine Speed R.P.M.	Oil Temperature Degrees F.
1000	175
1250	195
1500	210
1750	220
2000	230
2250	245
3000	260

It would seem in the case of any motor which will operate at 1000 R.P.M. and at an oil temperature of 175°F that any oil having a viscosity of 60 seconds Saybolt would adequately protect the working parts of the engine. This would mean that an S.A.E. 20 would qualify for all of the tractors and a great many of the combine and truck motors as well as the automobile. S.A.E. 30 would permit the oil heating to 215°F before any question as to protection of the working surfaces might be raised.

Oil Consumption

Another difficulty experienced by the engine user is excessive oil consumption. An oil may be adequately heavy for bearing protection and light enough for distribution, but still not heavy enough for economical oil consumption.

The tractor, combine motor and some of the trucks and automobiles are built with high grade light cast iron pistons, while other automobiles and trucks are equipped with aluminum pistons. There is a vast difference in the characteristics of these two pistons as to oil consumption. The aluminum piston is cut away to eliminate the difficulties of expansion due to high temperature. The oil mist of the crank case is exposed directly to the pistons and cylinders through the cut away sections. The greater clearance at the piston head and rings tends to make it impossible to hold the light oil, resulting in the need for heavier oils. The selection of viscosity of an oil for the automobile and truck or possibly any other engine is therefore largely based upon the oil consumption characteristic of the engine.

Too Heavy Oils Being Used

The Engineering departments of the tractor and automobile companies recommend viscosity specifications by S.A.E. numbers for their engines. The automobile companies in general recommend a high quality oil of S.A.E. 30 grade for summer, S.A.E. 40 when making long hard drives, S.A.E. 20 for fall and spring when the temperature is apt to be freezing, S.A.E. 10 for weather

down to zero and S.A.E. 10 with as much as ten per cent kerosene for temperatures to 30° below zero.

There are very few explicit instructions for trucks other than the above. There are no definite instructions for the proper lubrication of the combine motor. The combine motor operates under the most severe conditions, cold starting, and generally cold running with extremely dusty air conditions.

The recommendations for tractors are somewhat varied, but in general are as follows:

(A) S.A.E. 40 (Saybolt Universal viscosity of 60-74 seconds at 210°F) for warm weather. S.A.E. 30 with a low cold test for cold weather.

(B)	Viscosity 100°F	Viscosity 210°F	Pour	Carbon
Heavy oil (for summer, above 32°F)	650	67	40°F	.60
Light oil (for winter, below 32°F)	450	55	35°F	.50

S.A.E. 20 or 30 for cool or cold weather and S.A.E. 40 or 50 for warm or hot weather.

	Viscosity 100°F	Viscosity 210°F	Flash	Fire	Cold test
(C) Motor oil for summer use	625-50	66-68	440-50	500-10	35°F
(D) Motor oil for winter use	585	57-58	375	420	10°F

(E) For summer S.A.E. viscosity No. 60
For winter S.A.E. viscosity No. 50

The Engineers feel that the viscosity should be varied according to the temperature, S.A.E. 20 oil being recommended for winter, fall and spring, while S.A.E. No. 30, 40 and in some tractors even S.A.E. 50 and 60 is recommended for summer. We are finding complaints of excessive cylinder and piston wear, particularly where liners are replaced and new pistons are put in. This is undoubtedly due to the use of too viscous oil. The operator was probably using S.A.E. 50 oil before replacing the pistons and liners and almost invariably continues to use the same oil after overhauling the engine.

Upper Cylinder Lubrication

We are of the opinion that it is not possible to lubricate the pistons and cylinders of the tractor adequately when starting in the morning even with S.A.E. 20 oil, where the pistons and cylinders are fitted with the normal amount of clearance, until the oil has warmed up sufficiently to reduce the viscosity to the point where an adequate oil mist will be formed in the crank case.

We have felt for years that it is necessary to supplement the lubrication system with top lubrication of the pistons and cylinders by using lubricating oil in the fuel. The author has used oil in the gasoline with very marked results in his car. There is not sufficient oil to carbonize the cylinders or pistons or even to colour the exhaust. The oil does not effect the volatility of the fuel, and thus does not effect starting in the cold. The oil is carried into the cylinder by the high velocity of the air through the carburetor and intake manifold. It, however, settles out when the velocity is reduced and tends to lubricate

the pistons and cylinders from the top. We have experimented with different rates of mixture and have found that one pint to five gallons of fuel for summer and one quart to five gallons of fuel for winter is best.

Ellis (*3*) states "The fact is well established that, under ordinary conditions of operation, the cylinder wall does not receive a sufficient film of lubricant until about 10,000 engine revolutions have been performed irrespective of whether the system is splash or force feed."

He also states, "as approximately 60 to 70 or even 75% of cylinder wear eventuates during the period of 'no lubrication' or between starting-up time and the moment that there is a suitable oil film on the cylinder wall, it is obvious where we must look to find a solution of the problem of cylinder wear." Mr. Ellis favors a system of top oiling into the manifold, rather than by adding the oil to the gasoline.

Oil Should Not Be Thrown Away.

There have been many who have proven that oil does not wear out. Oil becomes contaminated with water, dirt, carbon fuel and possibly some excessive oxidation. It has been impossible for the farmer to obtain the value from the oil which he purchases, where it is only possible for it to be used from 30 to 60 hours in the engine.

Beck (*1*) and Penniman (*8*) have done considerable research work on motor coaches operated by the United Railways & Electric Co. of Baltimore. Penniman (*8*) outlines their experiences as follows: "The most important fact is that the first several hundred miles after putting in new oil, when the engine is supposed to be at its best, is the very worst time for operation of the vehicle, both in starting, running and in gasoline consumption. This means that the oil is entirely too high in viscosity. Our first interest is in clean properties of the oil, and then get as low viscosity as we can.

"Replying to questions, he said that the motor coaches did not have oil filters or rectifiers and he thinks that rectifying can be done better in the shop than on the engine. However he believes in air cleaners as the heavy grit settles in the crank case, and the case has to be taken down after 25,000 to 30,000 miles and cleaned.

"Oxidation however aids lubrication rather than the reverse, as it tends to increase the compression. He said that he is a great believer in using old oil; new oil oxidizes much easier when seeded with old oil. He is convinced that a certain amount of carbon or semi-oxidized product in oil actually aids its lubricating quality."

Pooley (*6*) states that oil changing is unnecessary. He runs his cars and trucks from the time they are bought until they are retired without changing the oil, but maintains the regulation oil level. This practice is the result of tests with the fleet that started about three years ago. He stated that his personal car had been driven 35,000 miles with no change, and that the companies fleet of light and heavy trucks have been run for mileages varying from 15,000 to 60,000 miles without oil changes. He referred his hearers also to the record of 80,000 miles without oil change made by Bruce (*2*).

Summary

As a result of our tests, we are definitely recommending the following:—

That oils used in internal combustion engines can be reclaimed and used again. The method of reclaiming may vary from straining the oils through canton cotton, blotting paper or felt strainers to the use of filters consisting of layers of soil and sand or leaving the oil in barrels for long periods of time, so that the heavy particles will settle to the bottom. The function of reclaiming the oil is to remove the dirt and water from the oils. No attempt is being made to remove the dilution caused by heavy fuels ends accumulating in the oil.

That the lightest oils which may be operated in the engine without excessive oil pumping be used.

That the oil should be strained each day and used over again and new oil be added to the crank case to maintain the proper level, where the engine is not equipped with an oil filter.

That a portion of the used oil be mixed with the fuel for use during at least the first twenty minutes of operation.

Great saving in engine operation can be affected where excessive wear is eliminated and the operating efficiency of the engine is increased.

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ENTOMOLOGICAL SOCIETY OF ONTARIO

PROCEEDINGS AND ABSTRACTS

The annual meeting of the Entomological Society of Ontario was held in Ottawa, December 1st and 2nd, 1932, in the Confederation Building. Prof. W. H. Brittain, Macdonald College, Quebec, presided at the meeting during which, in addition to the reading of papers, an evening public address entitled "Insects in Relation to Animal and Human Diseases" was given by Prof. Robert Matheson, of Cornell University. A social evening was also arranged at which Mr. D. Jenness, of the National Museum of Canada, gave a talk "Episodes in the Arctic" illustrated with moving pictures. Executive officers for the ensuing year are:—President, Prof. W. H. Brittain, Macdonald College, Quebec; Vice-President, Mr. W. A. Ross, Vineland Station, Ontario; Secretary-Treasurer, Mr. R. H. Ozburn, Ontario Agricultural College, Guelph, Ontario.

In addition to the president's address entitled, "The Balance Sheet of Entomology", the following papers were presented (the abstracts were prepared by the authors and the papers will be published in full presently in the "Annual Report of the Entomological Society of Ontario" or in "The Canadian Entomologist"):—

NOTES ON PEAR PSYLLA AND SAN JOSE SCALE CONTROL. W. A. Ross, T. Armstrong and D. F. Patterson, Entomological Laboratory, Vineland Station, Ont.

Laboratory and orchard experiments indicate that a 3% lubricating oil emulsion diluted in lime sulphur 1-9 is very toxic to pear psylla eggs; that it is as effective as the standard Ontario oil spray in preventing oviposition; and that it may be used with safety on pear trees. Experiments on the control of San Jose scale demonstrated that 3 and 4% lubricating oil sprays diluted either in water or Bordeaux mixture are practically 100% efficient and that lime sulphur 1-7, while very effective, kills more slowly than the oil emulsions. Brief reference is made to the behaviour of San Jose scale in Ontario from 1917 to 1932.

STUDIES ON THE EFFECTS OF BURYING AND OF CULTIVATION ON LARVAE OF THE ORIENTAL FRUIT MOTH. T. Armstrong, Entomological Laboratory, Vineland Station, Ont.

Small scale experiments demonstrate that many larvae, buried 2—6 inches in soil by fall and early spring ploughing, may work their way to the surface and give rise to moths; that there is no emergence of adults from pupae buried 2—6 inches; that regular orchard cultivation with a tractor disc, commenced prior to emergence and continued to mid-June, will destroy over 99% of the insects.

OBSERVATIONS ON THE RELATION OF TEMPERATURE AND MOISTURE TO THE ORIENTAL PEACH MOTH. G. G. Dustan and T. Armstrong, Entomological Laboratory, Vineland Station, Ont.

Data are presented showing the effects of temperature on the spring generation, pupation and emergence; on egg laying and the duration of the incubation period; and on the length of the larval feeding period. The minimum effective temperature for oviposition is between 57-58°F. The incubation period varies from 4 to 33.5 days at mean daily temperatures of 77.2° and 45.6°F. respectively. In cage experiments, a lack of moisture reduced egg deposition by slightly over three quarters and the life of the moths by one half.

SOME NEW FACTS CONCERNING THE GLADIOLUS THRIPS (*Taeniothrips gladioli* M. and S.). Alan G. Dustan and W. G. Matthewman, Entomological Branch, Ottawa, Ont.

The following points in this paper are of interest:--(1) The gladiolus thrips takes 14 to 17 days to mature and in Ontario there are 6 generations each season; (2) beside the gladiolus, sweet peas, carnations and canna lily are attacked to a limited extent in the field; (3) the insect failed to hibernate successfully outside in the Ottawa district during the winter of 1931-32; (4) there is a continual, though quiet, movement of the adults from one gladiolus patch to another during the entire season and a sudden, general exodus from infested beds in the autumn; (5) sprays and dusts in general failed to give much relief as a summer control in tests. The best known remedy is to free corms of thrips in the spring, prior to planting, by the use of dips or fumigants. A summer spray composed of Paris green and brown sugar, when applied early in the season showed distinct promise.

BLACKFLY CONTROL WITH LARVICIDES. C. R. Twinn, Entomological Branch, Ottawa, Ont.

Blackflies are bloodsucking pests affecting animals and man. One species transmits a serious protozoon blood disease of ducks. Blackflies breed in fast-running streams. Experiments show that miscible oils such as coal tar distillates, commonly sold as disinfectants, effectively destroy the larvae. The larvicide should be applied in sufficient quantity to make the water opaque white for three to five minutes. It may be used in small streams with little trouble and at low cost. In such concentrations the larvicide is, to some extent, injurious to fish and certain other forms of water life, but as the blackfly infestations are largely confined to rapids it would only be necessary, in most cases, to treat limited sections of rivers and streams, and the general fauna would thus not be materially or permanently affected. Further information on the flight range of blackflies is desirable.

SOME NOTES ON THE BIOLOGY AND LIFE-HISTORY OF PSOCIDS. L. R. Finlayson, Entomological Laboratory, Belleville, Ont.

The common book-louse, *Liposcelis* (*Troctes*) *divinatorius*, was found in very great numbers in *Sitotroga* breeding material at the Belleville Parasite Laboratory. It was definitely determined that this psocid and another species, undetermined as yet, will feed upon the living eggs of *Sitotroga cerealella*. It was found that *L. divinatorius* destroyed eggs in oviposition cans, thus greatly reducing host material for rearing *Trichogramma*, and it seems certain that this species was an important element in reducing the population of *Sitotroga* in breeding boxes.

SODIUM FLUORIDE AS A CONTROL FOR CATTLE LICE. R. W. Thompson, Ontario Agricultural College, Guelph, Ont.

Sodium fluoride applied as a powder or in solution has successfully controlled both biting and sucking lice on cattle in Canada and the United States. One ounce of powder, or one ounce dissolved in one gallon of water is adequate for the treatmet of a mature animal and costs about three cents. The method of application is described. A comparison with methods and substances in use on the Ontario farm at the present time is given.

ON THE FUNCTION OF AIR SACS IN INSECTS. G. J. Spencer, University of British Columbia, Vancouver, B.C.

INSECTS INFESTING GRAIN IN FARMERS' GRANARIES IN SOUTH-WESTERN ONTARIO. Geo. M. Stirrett and D. A. Arnott, Dominion Entomological Laboratory, Chatham, Ont.

The control of the grain insects found in farmers' granaries in the district is outlined and data are given of experimental fumigations carried out with carbon bisulphide and also with a proprietary fumigant.

SOME REMARKS ON FUMIGANTS. C. R. Twinn, Entomological Branch, Ottawa, Ont.

This paper briefly reviews the more important fumigants. Hydrocyanic acid gas is still the best and cheapest gas for general fumigation work. Several methods of generating it are outlined. In Ontario, this gas may be used only by licensed operators. Ethylene oxide-carbon dioxide is a comparatively new fumigant. Experiments reviewed show it to be remarkably penetrating and efficient. Used at the rate of 10-20 lbs. per 1000 cu. ft., at temperatures of 66-94°F., in fumigation vaults, during overnight periods, it destroyed species of household and stored product insects exposed under a variety of conditions, some of which were of an unusually exacting character. This fumigant is relatively non-toxic to humans and non-inflammable, and may be used without injurious effects to infested materials. It is best adapted to vault fumigation. Experiments with ethylene dichloride-carbon tetrachloride are also discussed. This is an efficient fumigant, but less penetrating than the former.

RECENT DEVELOPMENTS IN THE CORN BORER PARASITE SITUATION. Geo. Wishart and I. E. Thomas, Entomological Laboratory, Belleville, Ont.

A review of the work with the imported parasites of the European corn borer for the ten year period just completed indicates a very encouraging outlook. Several of the internal parasite species have become established at different points in Ontario and Quebec, and in Prince Edward county, Ontario, where liberations were concentrated in 1932, the parasitism secured has reached as high as 40% in certain areas.

THE CORN BORER SITUATION IN ONTARIO IN 1932. L. Caesar, Ontario Agricultural College, Guelph, Ont.

The corn borer increased in 1932 in most of the counties under the Act. The increase is attributed to very favorable weather for the insect in July and early August. The influence of weather upon the different stages is discussed.

PRACTICAL RESULTS OF BIOLOGICAL CONTROL AS APPLIED TO INSECTS. A. B. Baird, Entomological Laboratory, Belleville, Ont.

This paper reviews briefly the various introductions of parasitic and predacious insects which have been carried out in Canada. These include enemies of the following pests: larch sawfly, gipsy moth, brown-tail moth, satin moth, pine shoot moth, oriental fruit moth, European corn borer, European lecanium scale, European earwig, oyster shell scale, greenhouse white-fly, and wheat stem sawfly. In many cases the practical value of the introduction of these insect enemies has been definitely established.

A SUCCESSFUL PARASITE INTRODUCTION INTO BRITISH COLUMBIA. R. Glendenning, Dominion Entomological Laboratory, Agassiz, B.C.

The European plum scale, *Eulecanium coryli* (L) became a serious pest in the Vancouver district of British Columbia about 1925, and control by spraying cost

the city of Vancouver alone nearly $1000 annually. A large number of hosts are favoured by this insect, the principal damage being to shade and boulevard trees, and roses. In 1928 and 1929 adults of the chalcid, *Blastothrix sericea* Dalm. received from England were liberated by officers of the Dominion Entomological Branch. The insects spread with amazing rapidity over the entire 200 square miles of infested territory. Examinations made in 1931 showed from 10 to 95% of the host to be parasitized, and as a result, the number of scales per foot of twig on infested trees dropped in 1930 from a maximum of 80 to 35. This has since been further reduced to a maximum of 2 per foot, and this insect is no longer numerous enough to need artificial control measures.

DESIGN OF A NEW TYPE OF LIGHT TRAP TO OPERATE AT CONTROLLED INTERVALS. H. L. Seamans and H. E. Gray, Entomological Laboratory, Lethbridge, Alberta.

A multiple light trap, operating at controlled intervals, co-ordinated by means of a clock, is described in this paper. By this means a considerable amount of data may be secured in regard to the flight activity of night-flying insects.

THE EXTERNAL PARASITES OF TWO BIRDS INTRODUCED INTO BRITISH COLUMBIA. G. J. Spencer, University of British Columbia, Vancouver, B.C.

A CO-OPERATIVE INVESTIGATION OF THE QUANTITATIVE RELATION BETWEEN SUMMERFALLOW METHODS AND THE WIREWORMS IN SASKATCHEWAN; A PROGRESS REPORT. K. M. King and R. Glen, Entomological Laboratory, Saskatoon, Sask.

These wireworm investigations are being carried on as a co-operative project by the Dominion Entomological Laboratory, at Saskatoon, and the Experimental Station, at Swift Current. Due to the nature of the problem, new methods of study had to be invented and tested, the data throughout being subjected to statistical analysis. Four types of summer fallow culture (1) the common method, (2) with July ploughing, (3) surface cultivation, and (4) excessive tillage, are under study. Surface cultivation involving shallow tillage only, proved to be the most promising fallow method tested, as well as being the cheapest, and lending itself to favour from the point of view of the control of weeds and soil drifting. (Abstract prepared by H. G. Crawford).

THE GRASSHOPPER CAMPAIGN IN MANITOBA IN 1932. A. V. Mitchener, University of Manitoba, Winnipeg, Man.

One of the worst outbreaks of grasshoppers in the history of Manitoba occurred during the summer of 1932. About one-third of the grain growing area of the province, centering on the Red River valley, was affected. In the eastern part of the infested area the clear-winged grasshopper (*Camnula pellucida* Scudd.) was most abundant. Associated with this species was the two-striped grasshopper (*Melanoplus bivittatus* Say) although not so abundant. In the western part of the infested area the lesser migratory grasshopper (*Melanoplus mexicanus* Saussure) was most destructive. Sodium arsenite in the liquid form replaced almost entirely other forms of poison in the bait which was used over the whole area. The use of the poisoned bait saved millions of bushels of grain from being destroyed.

THE PRESENT STATUS OF THE EUROPEAN PINE SHOOT MOTH IN SOUTHERN ONTARIO. R. W. Sheppard, Entomological Branch, Niagara Falls, Ont.

Seven years ago the European pine shoot moth was discovered causing serious injury to pine plantations in a large proportion of the nurseries, parks, cemeteries and private estates of southern Ontario. Eradication of this pest was attempted and some degree of control and protection has undoubtedly been afforded to the pines. The measure of control gained in the older infested areas has now been somewhat nullified by the recent discovery of infestations in the reforestation plots, along the shore in Welland county. The most serious infestations are in the vicinity of Port Colborne and are spread through the western section of Welland and, in widely scattered plantations, through Haldimand county to the Norfolk border. General observations would appear to indicate that we cannot, at the present time, look for any great measure of control of the European pine shoot moth by native parasites, predators or diseases.

THE EUROPEAN PINE SHOOT MOTH. J. J. deGryse, Entomological Branch, Ottawa, Ont.

The Cedar bay laboratory was established in the hope that new methods might be evolved for the control of the European pine shoot moth. An intensive study of the biology of the insect under Canadian conditions has been begun. Several important biological aspects of the problem have been investigated and a number of sprays have been tested during the summer of 1932. There is every reason to believe that a commercial control by spraying may eventually be developed.

CONTROL OF THE LOCUST BORER BY FOREST MANAGEMENT. A. H. MacAndrews, New York State College of Forestry, Syracuse University, Syracuse, N.Y.

Cyllene robiniae, Forst., the locust borer, is the worst enemy of black locust in the East. Two thousand trees were cut and classified by crown class and examined for injury. In the codominant class, trees over 3 inches in diameter showed a marked reduction in the number of successful attacks. The 2 inch suppressed trees had the largest number of attacks and acted as brood trees from which large numbers of beetles emerged to attack adjoining trees. Their removal is necessary for the protection of the stand.

FOREST INSECTS OF THE SEASON IN THE MARITIMES AND GASPE PENINSULA. R. E. Balch and L. J. Simpson, Entomological Laboratory, Fredericton, N.B.

Notes on the more important species of insects active in forests of the region in 1932. Particular reference is made to the European species, *Diprion polytomum* (Hartig), *Cryptococcus fagi* Bsp., and *Dreyfusia piceae* (Ratz.), with remarks on distribution, damage, and natural control.

APPLICATION OF CHEMICALS TO THE SOIL SURFACE AS A PRIMARY FACTOR IN WHITE GRUB CONTROL. G. H. Hamond, Entomological Branch, Ottawa, Ont.

Investigations in the treatment of sod surface with insecticides to deter June beetles from depositing eggs has been in progress for four years. Superfine sulphur dust gave an average of 87.8% protection, dry lime sulphur 90.0%, lime and 50% coarse sulphur 83.4%. Ten per cent superfine sulphur in hydrated lime gave excellent

protection from first year grubs, where the sod of check areas and avenues between plots was destroyed. The "Latin Square" method of plot arrangement was employed. A 'six-by-six' series allowed the use of one check plot and five quantities of material in each row. Under commercial conditions materials can be distributed through the fertilizer attachment of a seed drill.

NOTES ON SOME OF THE MORE INJURIOUS INSECTS OF THE SEASON 1932 IN CANADA. NOVA SCOTIA, F. C. Gilliatt; NEW BRUNSWICK, R. P. Gorham; QUEBEC, G. Maheux and C. E. Petch; ONTARIO, Prof. L. Caesar and W. A. Ross; MANITOBA, Prof. A. V. Mitchener and N. Criddle; SASKATCHEWAN, K. M. King; NORTHERN ALBERTA, Prof. E. H. Strickland; SOUTHERN ALBERTA, H. L. Seamans; BRITISH COLUMBIA, E. R. Buckell.

Reviews of the entomological circumstances of the year in terms of the rise or fall of species of importance in the several provinces of the Dominion.

RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

Etude comparee des prix de l'Orge et des Porcs en Saskatchewan. C. J. Wilkinson, Université de la Saskatchewan, Saskatoon. Article reçu pour publication le 1er juin 1932. 7 pages.

L'auteur essaie d'établir une relation entre le prix de l'orge et le prix des porcs en vue de déterminer la tendence probable de la production porcine. Une relation analogue est en usage aux Etats-Unis depuis quelque temps.

Pendant la période 1910-1929, 17.3 boisseaux d'orge No. 3 C. W. ont égalé en valeur 100 livres de porc sur pied en Saskatchewan. Le rapport entre les prix de l'orge et des porcs paraît varier davantage que le rapport entre les prix du maïs et des porcs. 1930 et 1931 ont été les années les plus profitables pour la production des porcs en Saskatchewan depuis 1910.

Traitement des Pommes de Terre de Semence pour le Controle de la Galle Commune. G. B. Sanford, Laboratoire Féderal de Pathologie Végétale, Edmonton, Alta. Article reçu pour publication le 1er septembre 1932. 12 pages.

La conclusion de l'article est que les méthodes actuellement recommandées pour la désinfection des tubercules de semence en vue de réduire la galle commune sont pratiquement sans valeur lorsqu'on les applique aux conditions de la grande culture.

Observations sur le Developpement du Ver du Coecum chez les Volailles. Alex. D. Baker, Collège Macdonald, P.Q. Article reçu pour publication le 25 mai, 1932. 8 pages.

L'auteur fait ressortir certaines conceptions fausses concernant l'identité de cette espèce de ver intestinal, et fournit quelques renseignements exacts sur la vie de ce ver. L'auteur a trouvé que la maladie de la tête noire apparaît fréquemment deux ou trois semaines après l'infection de l'oiseau par le ver du coecum.

Etudes sur les Vitamines A et D. pour les Poussins en Croissance. H. S. Gutteridge, Ferme Expérimentale Fédérale, Ottawa, Ont. Article reçu pour publication le 5 juin 1932. 7 pages.

Cette étude compare l'huile de foie de morue avec l'huile de sardines comme source de vitamine A.

L'addition d'huile de sardines ou d'huile de foie de morue à une ration pauvre en vitamine A. a augmenté la croissance et empêché l'apparition des maladies résultant de l'absence de cette vitamine. Cependant ni l'huile de sardines ni l'huile de foie de morue incorporées à la ration au taux de 1 ou 2% n'ont fourni sufissamment de vitamine A. pour provoquer une croissance aussi rapide qu'une ration bien balancée. Les deux huiles semblent d'égale valeur en ce qui concerne la vitamine A, l'avantage, s'il y en a, étant plutôt pour l'huile de sardines.

Etudes sur le Vim Oat Feed. I. La Digestibilite du Vim Oat Feed. F. W. Muir et C. J. Watson, Ferme Expérimentale Centrale, Ottawa, Ont. Article reçu pour publication le 3 novembre 1932.

Cet article est le premier rapport sur un travail entrepris dans les nouvelles stalles installées à la Ferme Expérimentale Centrale pour l'étude des phénomènes

de digestion. Le travail est fait en coopération par les Divisions de Zootechnie et de Chimie de la Ferme Expérimentale. Le présent article est le premier d'une série de quatre qui seront publiés dans "La Revue Agronomique".

Le Vim Oat Feed est un aliment concentré faisant l'objet d'une campagne d'annonce intensive et qui est fait principalement avec de la balle d'avoine. Les résultats de cette étude préliminaire indiquent que le coefficient de digestibilité du Vim Oat Feed est bas comparé à celui d'autres aliments comme le foin mélangé, le foin de fléole et la paille d'avoine. Quand le Vim Oat Feed est mélangé à du fourrage la digestibilité de la ration totale est décidement plus basse qu'on pourrait s'y attendre en considérant les digestibilités du Vim Oat Feed et du fourrage pris sépàrément. En se basant sur sa teneur en éléments digestibles le Vim Oat Feed possède une valeur alimentaire inférieure à la moitié du son ou de l'avoine et d'environ les trois quarts du foin mélangé, du foin de fléole ou de la paille.

Remarques sur la Lubrication des Tracteurs. E. A. Hardy, Université de la Saskatchewan, Saskatoon. Article reçu pour publication le 15 juin 1932. 7 pages.

Le Professeur Hardy décrit les divers systèmes de lubrication actuellement utilisés pour les moteurs dans l'Ouest du Canada. Il décrit également la classification des huiles. Après une étude approfondie de l'usure des moteurs, le Professeur Hardy en arrive à la conclusion que les huiles généralement employées sont trop lourdes, et ne permettent pas une lubrication éfficace lors de la mise en marche où par temps froid. Il recommande la rectification de l'huile usagée afin de pouvoir l'utiliser plus longtemps. Cette huile usagée possède certaines propriétés qui lui permettent d'augmenter l'efficacité de l'huile neuve dans certaines conditions.

REGINA CONVENTION PROGRAMME

Officers of the C.S.T.A. and affiliated organizations and groups have been cooperating with officials of the World's Grain Exhibition and Conference in the building of a programme for the meetings next July. Under the Chairmanship of Dr. E. S. Archibald, the Programme Committee of the Grain Exhibition and Conference has been in communication with a large number of scientists from other countries and a considerable number of outstanding men have signified their intention of being present. The Programme Committee met in Regina on January 28th and proceeded to lay out a tentative programme. Details of this are not available for the current issue of *Scientific Agriculture,* but will be given in the next issue.

The General Secretary of the C.S.T.A., H. L. Trueman, attended the meeting in Regina and is visiting the western branches of the Society, returning to Ottawa about February 20th.

CONCERNING THE C.S.T.A.

NOTES AND NEWS

A. D. Baker (McGill '23) formerly closely associated with the development of parasite work at Macdonald College, is at present carrying on animal parasite research work as a member of the staff of the Department of Biology, University of Toronto.

R. M. Lewis (Toronto '21) is continuing post-graduate work in the Department of Botany, University of Toronto.

T. G. Raynor (Toronto, '89) formerly District Seed and Feed Inspector, Dominion Seed Branch, Ottawa, is now engaged in the seed grain business with the C. W. Hall Company Ltd., hay and grain dealers, of Ottawa, Ont.

W. Southworth (Toronto '12) who has been working on the development of a high seed producing strain of alfalfa at Aberystwyth, Wales, is continuing his investigations at Rothamsted Experimental Station and also at the Woburn Experimental Station, Bedfordshire, England.

E. R. Lewis (Alberta '29) has changed his address from Edmonton to Winterburn P. O., Alberta.

W. K. Bunner (Toronto '23) is teaching in the Thorold High School.

J. F. Booth (Saskatchewan '19) Commissioner of the Agricultural Economics Branch, Dominion Department of Agriculture, Ottawa, was elected Vice-President of the American Farm Economics Association at the recent meeting in Cincinnati, Ohio.

H. A. Derby (Toronto '23) has recently been appointed Chief of the Dairy Markets and Cold Storage Division of the Dairy Branch at Ottawa. Dr. Derby graduated from the Dairy School at Kingston in 1918 and from the Ontario Agricultural College, Guelph, in 1923. For five years he acted as Creamery Inspector and Instructor in butter making in Alberta. He received his master's degree at Ames, Iowa, in 1928, and his doctor's degree in 1931. Previous to coming to Ottawa he was Director of Research with the Dairy Corporation of Canada.

W. V. Longley (Toronto '11) who has been on the sick list for some time was able to attend the C.S.T.A. annual meeting and the meeting of his extension workers at the Agricultural College at Truro early in January. Dr. Longley has made good progress and is gradually assuming his regular duties.

L. C. Harlow (Cornell '99) Professor of Chemistry at the Nova Scotia Agricultural College, has been confined to his home with illness for some time.

ADDITIONS TO EDITORIAL BOARD OF *SCIENTIFIC AGRICULTURE*

The increased application of statistical methods to research in agriculture has necessitated the appointment of two new members to the Editorial Board of *Scientific Agriculture.* While certain of the Editors have familiarized themselves with statistical methods as applied to their own particular fields of agricultural research, these men do not consider themselves mathematicians. Both of the men appointed have had special training in mathematics. Their services will be available to check the applications of statistical methods in papers submitted to *Scientific Agriculture* and they will also be glad to advise members regarding the suitability of new methods to special cases.

J. W. Hopkins, of the Division of Biology and Agriculture, National Research Laboratories, Ottawa, is a graduate of the University of Alberta. He did post-graduate work at Edmonton in Cereal Chemistry. During the last two years he has been at Rothamsted Experiment Station, Harpenden, England, where he specialized in statistical methods. During this time he held the position of Research Assistant, Associate Committee on Grain Research, National Research Council. At present he holds the position of Junior Research Biologist. The combination

of training in chemistry, biology, and mathematics which Mr. Hopkins has received makes his services particularly valuable to Canadian research workers.

R. C. Moffat, of the Department of Agricultural Engineering, Ontario Agricultural College, Guelph, graduated in mathematics and physics from the University of Toronto in 1916 and received his M.A. degree in physics in 1917, becoming a member of the staff of the Ontario Agricultural College in that Fall. Since then Professor Moffatt has taken a postgraduate course in statistical methods under Professor Kemp, Department of Economics, University of Toronto, and a course in "Least Squares" under Dr. Satterley, Associate Professor of Physics, University of Toronto. Professor Moffatt has been developing a course in statistical methods which is somewhat broader than most of the courses in this subject given at our Agricultural Colleges, as it deals with the application of statistics to almost every branch of Agriculture.

CURRENT PUBLICATIONS

THE SURPLUS FARMER. Bernard Ostrolenk. Harper Brothers, New York and London, 1932. 135 p. Edited by P. T. Homan.

This is the first of a series of small books on contemporary economic problems dealing with public utility regulations, international economic relations, industrial combinations, taxation, business cycles, labour organization, and control of corporations.

In the introduction the author states that hitherto our educational machinery has been directed either toward increased or more efficient production but that during the past five years the surplus has become the central theme of discussion.

In seeking a solution one group suggests raising tariffs, thus increasing domestic prices while dumping the surplus abroad at world prices. This group includes those favouring debenture or equalization schemes and stabilization corporations sponsored by the Farm Board. A second group favours co-operative marketing and commodity control by farmers to enhance prices. Finally, a third group favours adjustment of production to domestic consumption.

It is stated that urban dwellers lack interest in the farm problem because surplus production has meant lower prices, higher real wages for urban workers and no important diminition in purchasing power of the 27,000,000 people living on farms. The author points to the fact that in a nation as highly industrialized as the United States the majority of the people can enjoy prosperity for a considerable period while the minority—agriculture in this case—experience relative depression. It is not stated how long such a state can continue but it is recorded that the disparity continued throughout the period 1920-30.

The agricultural problem is discussed under the following headings: The era of land development; The agricultural revolution; The agricultural surplus; The agricultural export trend; A practical lesson in farm relief; and Problems in agricultural adjustments.

Discussing ways of adjusting production to demand and thus contributing to a solution of the problem the author suggests the elimination of the submarginal farmer and submarginal land through the creation of a state or national fund and the purchase of such land by these bodies; the encouragement of industries to locate in the open country thus giving country people a chance to supplement farm with factory income; abandonment of reclamation and irrigation schemes; careful consideration of freight rates to the end that new territory shall not be brought into competition with producing areas; and concludes with the observation that "encouraging further agricultural development by artificial temporary price levels is in no sense sound social direction". —J. F. Booth.